# MARYLAND
# GEOLOGICAL SURVEY

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## ANNE ARUNDEL COUNTY

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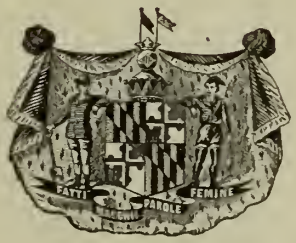


## ANNE ARUNDEL COUNTY

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# LETTER OF TRANSMITTAL

To His Excellency Emerson C. Harrington,

Governor of Maryland and President of the Geological Survey Commission.

*Sir:*—I have the honor to present herewith a report on The Physical Features of Anne Arundel County. This volume is the eighth of a series of reports on the county resources, and is accompanied by large scale topographical, geological, and agricultural soil maps. The information contained in this volume will prove of both economic and educational value to the residents of Anne Arundel County as well as to those who may desire information regarding this section of the State. I am,

Very respectfully,

Wm. Bullock Clark,

*State Geologist.*

Johns Hopkins University,
Baltimore, *March, 1916.*

# CONTENTS

# ILLUSTRATIONS

# PREFACE

This volume is the eighth of a series of reports dealing with the physical features of the several counties of Maryland.

*The Physiography of Anne Arundel County,* by Homer P. Little, comprises a discussion of the surface characteristics of the county, together with a description both of the topographic forms and of the agencies which have produced them.

*The Geology of Anne Arundel County,* by Homer P. Little, deals with the stratigraphy and structure of the county. An historical sketch is given of the work done by others in this field, to which is appended a complete bibliography. Many stratigraphical details are presented, accompanied by local sections.

*The Mineral Resources of Anne Arundel County,* by Homer P. Little, deals with the economic possibilities of the various geological deposits of the county. Those which have been hitherto employed are fully discussed, and suggestions are made regarding the employment of others not yet utilized.

*The Soils of Anne Arundel County,* by J. C. Britton and C. R. Zappone, Jr., contains a discussion of the leading soil types of the county and their relation to the several geological formations. This investigation was conducted under the direct supervision of Professor Milton Whitney, Director of the Bureau of Soils of the U. S. Department of Agriculture.

*The Climate of Anne Arundel County,* by Oliver L. Fassig, is an important contribution to the study of the climatic features of the county. Mr. Fassig is Section Director in Baltimore of the U. S. Weather Bureau, and is also Meteorologist of the Maryland State Weather Service.

*The Hydrography of Anne Arundel County,* by B. D. Wood, gives a brief account of the water supply of the county, which, as in the case of the other Coastal Plain counties, affords but little power for commercial purposes.

*The Magnetic Declination in Anne Arundel County,* by L. A. Bauer, contains much important information for the local surveyors of the county. Dr. Bauer has been in charge of the magnetic investigations since the organization of the Survey and has already published two important general reports upon this subject. He is the Director of the Department of International Research in Terrestrial Magnetism of the Carnegie Institution.

*The Forests of Anne Arundel County,* by F. W. Besley, is an important contribution and should prove of value in the further development of the forestry interests of the county. Mr. Besley is State Forester of Maryland.

The State Geological Survey desires to extend its thanks to the several national organizations which have liberally aided it in the preparation of several of the papers contained in this volume. The Director of the U. S. Geological Survey, the Chief of the U. S. Weather Bureau, the Chief of the U. S. Forest Service and the Chief of the Bureau of Soils of the U. S. Department of Agriculture have granted many facilities for the conduct of the several investigations and the value of the report has been much enhanced thereby.

# THE PHYSICAL FEATURES OF ANNE ARUNDEL COUNTY

# DEVELOPMENT OF KNOWLEDGE CONCERNING THE PHYSICAL FEATURES OF ANNE ARUNDEL COUNTY WITH BIBLIOGRAPHY

BY

HOMER P. LITTLE

## Introductory

The first mention of the physical features of Anne Arundel County, as is the case with most of the region bordering on Chesapeake Bay, is found in Captain John Smith's account of his travels. This account is based on an exploration made in 1608, the results of which were published in London, in 1624, with other papers, under the title: "A Generall Historie of Virginia, New England, and the Summer Isles, etc." From that time to the present papers have been continually appearing which dealt either directly with the physical features of Anne Arundel County, or gave statements of a general nature which might be applied there as elsewhere. The most important of these will be briefly discussed in the following paragraphs, first those of a general bearing; then those which refer to particular geological horizons of the county beginning with the Potomac and proceeding successively up the scale through the Pleistocene; and lastly will be appended a bibliography of the publications consulted in the preparation of this report.

## Historical Review

### General contributions

As stated above, the first source of general information concerning Chesapeake Bay is to be found in Smith's "Generall Historie of Virginia,

New England, and the Summer Isles, etc." Smith's description of that part of the Coastal Plain which came under his observation is summarized by him as follows:

"The vesture of the earth in most places doth manifestly prove the nature of the soyle to be lusty and very rich. The color of the earth we found in divers places, resembleth bole Armoniac, terra sigillata ad Lemnia, Fuller's earth, marls, and divers other such appearances. But generally for the most part it is a black sandy mould, in some places a fat slimy clay, in other places a very barren gravel . . . . Thirtie leagues Northward [from the Patuxent] is a river not inhabited . . . .: for the red clay resembling bole Armoniac we called Bolus" [= Patapsco].

The next publication of real importance and one which is universally regarded a classic, is that of William Maclure, first printed in 1809 and republished with elaboration in 1817. This work is entitled "Observations on the Geology of the United States of America, with some remarks on the effect produced on the nature and fertility of soils by the decomposition of the different classes of rocks." A point of special interest is that this volume contains the first published geological map of the United States. As to the geology of the country, three divisions only are recognized: the Primitive, the Secondary or Transitional, and the Alluvial. In this last falls all the Coastal Plain of Maryland. Speaking of the origin of the Alluvial, Horace H. Hayden, in an interesting volume published in Baltimore, three years later, says:

"Viewing the subject in all its bearings, there is no circumstance that affords so strong an evidence of the cause of its formation as then that of its having been deposited by a general current which, at some unknown period, plowed impetuously across the whole continent of America, and that from northeast to southwest." Of further interest is the mention by the same author of the fossil remains of fish, terrapin, mollusca, and especially of the teeth of the Asiatic elephant, on the Western Shore of Maryland.

A most pronounced forward step was made in 1823 when John Finch, an Englishman traveling in America, made the suggestion in an oral

communication to the Philadelphia Academy of Natural Science "that what is termed the alluvial formation, in the geological papers of Messrs. Maclure and Cleaveland, is identical and contemporaneous with the newer secondary and tertiary formations of France, England, Egypt, and Hindoostan." The "Diluvial" is explained thus:

"After the production of these regular strata of sand, clay, and limestone, &c. came a terrible irruption of water from the north or northwest, which in many places covered the preceding formations, with diluvial gravel, and carried along with it those immense masses of granite, and of the older rocks, which attest to the present day the destruction and ruin of a former world."

The thirties and early forties saw, through the efforts of Morton, Say, Lea, and especially of Conrad, a continuation and pronounced refinement of the idea of correlation and nomenclature introduced by Finch. These men all collected and identified many fossils, the value of which from a geological standpoint had, up to that time, been inadequately recognized in this country. In 1828 Morton had published the notes of Professor Vanuxem in which the Cretaceous age of certain deposits was asserted; he continued to hold this idea although Eaton considered this "Ferruginous Sand Formation" as genuine Tertiary. Among the fossil forms cited by Morton in support of his view is "alcyonia" from "the greensand below Annapolis." In 1832 and 1833 Conrad published the description of a large number of Tertiary forms. In 1833 Lea published his "Contributions to Geology," in which the following important paragraph occurs:

"After a careful examination of a great number of genera and species from the Tertiary of Claiborne, Alabama, I had no hesitation in referring them to the same period as the London Clay of England, and the Calcaire Grossier of Paris .... This part of the Tertiary formation .... is called by Mr. Lyell the Eocene period."

Thus for the first time the term "Eocene" was applied to American deposits. Conrad, the following year, accepted the term and applied it at several localities, so that the name Eocene soon became firmly fixed in American literature. The same author, in 1838, proposed the classification

of the Tertiary into the Upper Tertiary (Newer Pliocene), the Medial Tertiary (Older Pliocene), and the Lower Tertiary (Eocene). The Medial Tertiary was correlated with the Crag of England which Conrad considered Older Pliocene. In 1841 he again correlated his Medial Tertiary with the Crag which, however, he was now convinced was Miocene. About this time Lyell referred to the Miocene of Maryland—for the term "Miocene" had already been applied to certain strata of Maryland in 1836 by W. B. Rogers and had been tentatively accepted by Ducatel—as more closely related to that of Lorraine and Bordeaux.

The term Pliocene, as now applied to the marine strata of the Atlantic Coast, was first used by Professor Michael Tuomey, in 1846. Post-Pliocene or Pleistocene, as applied to deposits of latest Tertiary age, was first used by H. D. Rogers, in 1844, in an address delivered at the meeting of the Association of American Geologists and Naturalists.

Thus by the end of 1846 there was introduced a nomenclature for the major divisions of the Mesozoic and Cenozoic of the Atlantic Coastal Plain similar to that employed at present, to wit: Cretaceous, Eocene, Miocene, Pliocene, and Pleistocene. The development of smaller subdivisions within each of these, beginning with the oldest, will now be discussed.

### THE LOWER CRETACEOUS

This group of strata which rests on the ancient crystalline surface and extends to the marine beds above, was long recognized as belonging somewhere in the Jurasso-Cretaceous series, but whether entirely Jurassic in age, or in part Jurassic and in part Cretaceous, or whether entirely within the limits of the Cretaceous period, has been a debated question.

W. B. Rogers, in 1840, differentiated these deposits in Virginia from the older Mesozoic deposits to the west and called them Upper Secondary. Later he refers them "at least in part to the Upper Jurassic," and still later to the Jurasso-Cretaceous. Tyson, in 1860, recognized in the Cretaceous of Maryland a lower "group" consisting of sands and clays. In this lower group he differentiated the "iron ore clays" which Fontaine, in Monograph XV of the U. S. Geological Survey, made equivalent to his

Upper Potomac or "Variegated Clay Group." Professor Cook, in 1868, recognized that the Cretaceous of New Jersey could be divided by fossil content into several distinct series; the oldest of these he called the "Plastic Clay," and on the authority of Meek and Hayden referred it to the "Earlier Cretaceous." Conrad, in 1869, employed the name "Raritan" for certain of the lower beds in New Jersey, but the first use of the term as a formation name was by Clark in 1892 for the New Jersey deposits.

The term "Potomac formation," which is now used as a group name to include all the sands and clays of the Lower Cretaceous, was first suggested by McGee in 1885, who, on the ground that the flora was too unique to be definite, and because Marsh found the vertebrate remains to be distinctly Upper Jurassic, assigns the Potomac to that period.

McGee's term, "Potomac," was generally accepted and, since this series of deposits offered an attractive field of research, several workers were soon actively engaged in unravelling its stratigraphy. Fontaine, Uhler, Marsh, Ward, Darton, and somewhat later Clark and Bibbins, and Berry, all worked to a greater or less extent in this field, and each group of men entertained pronounced ideas as to the age of the group and the best system of nomenclature for its component parts. Fontaine, in Monograph XV, U. S. Geological Survey, on "The Potomac or Younger Mesozoic Flora," divided the "formation" into a Lower Member and an Upper or Variegated Clay "Group." Ward, in 1888, stated that he would not be surprised if the final verdict of science placed the lower plant-bearing horizons of the Potomac in the Jurassic, though he adds that "according to the ordinary method of arguing from similar statistics [proportion of dicotyledonous plants] the sum of all the facts here presented would make the Potomac, considered from the point of view of the flora alone, homotaxially equivalent to the Wealden of England and North Germany, now usually included in the Cretaceous system." In 1893-1894 the same author offered a detailed classification of the Potomac group of Maryland and Virginia as follows:

| | |
|---|---|
| Newer Potomac | Upper Albirupean. |
| | Lower Albirupean. |
| Middle Potomac | Aquia Creek. |
| Basal Potomac | Mount Vernon. |
| | Rappahannock. |
| | James River. |

All of these, with the possible exception of the Basal Potomac, were placed in the Cretaceous.

Uhler meanwhile had been carrying on investigations in Maryland, and in 1890 he classified the unconsolidated deposits below the marine Cretaceous into the "Potomac"—which he had formerly designated "Baltimorean"—the "Albirupean," and the "Alternate Clay Sands."

It will be noticed that much of the work referred to above, which placed part at least of the Potomac group in the Lower Cretaceous rather than in the Jurassic, had been carried on by paleobotanists. They based their conclusions on the relative abundance of monocotyledonous and dicotyledonous plants found in these deposits. In opposition to the paleobotanists stood the emphatic statement made by Marsh that investigations in the realm of vertebrate paleontology had "proved conclusively that the Potomac formation, as shown in its typical localities in Maryland, is of Upper Jurassic age." Clark and Bibbins, in 1897, proposed the following formation names and attempted to reconcile the conflicting views as follows:

| | | |
|---|---|---|
| Lower Cretaceous | Raritan formation | Potomac Group. |
| | Patapsco formation | |
| Upper Jurassic (?) | Arundel formation | |
| | Patuxent formation | |

Later, in 1911 and again in 1916, in the Maryland cretaceous reports, Clark, Bibbins and Berry adopted the following interpretation based on the work of Berry on the floras and Lull on the dinosaurs.

| | |
|---|---|
| Upper Cretaceous | Raritan. |
| Lower Cretaceous (Potomac Group) | Patapsco. |
| | Arundel. |
| | Patuxent. |

## THE UPPER CRETACEOUS

The Upper Cretaceous deposits of the Atlantic Coastal Plain had been little differentiated before 1868. In that year Professor George H. Cook published his important volume on the "Geology of New Jersey," in which he divided the Upper Cretaceous into two major series, each with several subdivisions. These major series were classified according to their economic uses and consisted of the "Clay Marl Series," overlain by the "Marl Series." A third series, the Plastic Clay, has been referred to in the discussion of the Lower Cretaceous. Cook's classification was not improved upon for many years, in fact not until after W. B. Clark began his work in 1891. In his final classification the Clay Marl series of Cook was practically unchanged in its limits, but the geographic term "Matawan" was substituted. Instead of the Marl series three geographic names of coordinate value with Matawan were employed, which in ascending order are: Monmouth, Rancocas, and Manasquan. Each of these is again divided into smaller units. Clark and his assistants traced the Cretaceous deposits southward into Maryland, where it was found that all the major divisions of the Cretaceous of New Jersey, except the Rancocas and Manasquan, could be readily identified. It was found impossible, however, to differentiate these into smaller units, as had been done northward, with the result that the group terms Matawan, Monmouth, and Rancocas of New Jersey become in Maryland formational names.

In 1893 Darton described "an arenaceous formation not hitherto discriminated, lying between the Potomac and Severn formations in the upper Chesapeake Bay region." This formation, which in its type locality corresponds closely with Uhler's Atlantic City Sands, Darton designated the Magothy formation. Until very recently this, with the formations of Clark described above, constituted the Upper Cretaceous of Maryland as generally accepted. In 1908, however, due to the work of Berry, the Raritan was separated from the Potomac group, making the Upper Cretaceous sequence of Maryland—Raritan, Magothy, Matawan, Monmouth, and Rancocas.

### THE EOCENE

The Eocene, as already pointed out, was recognized as early as 1833. In spite of this, and in spite of the early development of a detailed classification in Alabama, the Eocene strata of the Middle Atlantic Slope were not subdivided for many years. Heilprin, in 1881, in a "Note on the Approximate Position of the Eocene Deposits of Maryland," pointed out the very close relation of *Ostrea compressirostra* and *Cucullæa onochela* with the European species *Ostrea bellavacina* and *Cucullæa crassatina*. He then says:

"If such observations are of any value stratigraphically we may fairly look upon the Maryland Eocene deposits—the Piscataway sands below and the Marlborough rocks above—as representing a horizon nearly equal to that of the Thanet Sands of England and the Bracheux sands of the Paris basin or of the British Bognor rock (= London Clay). In either case they would be near the base of the series." In the American succession he would place them as probably near the base of the Buhrstone or possibly even lower, the equivalent of the Eolignitic.

During the years immediately succeeding this Uhler published several notes on the Eocene of the Western Shore of Maryland.

Even at this date little really satisfactory knowledge of the Eocene of the region under discussion existed. It was indeed so meager that Clark, writing as late as 1891 in Bulletin 83 of the U. S. Geological Survey, said:

"The Eocene deposits of Maryland must be considered to represent a single horizon until a more detailed examination of the range of the different fossil forms affords evidence for a division upon that basis."

From this time on, however, rapid progress was made. Darton, in 1891, proposed the term "Pamunkey formation" for the Eocene. In 1895 Clark divided the Eocene into the "Aquia Creek Stage," in which he found a fauna "decidedly lignitic in character" and into the "Woodstock Stage" in which he found forms "identical or closely related to Claiborne types." Comparing these deposits with those of the Gulf region he says that he is "strongly of the opinion, upon both geological and paleontological grounds, that the Eocene deposits of the Middle

Atlantic slope represent the greater portion of the Eocene series of the Gulf, its highest members alone excepted." In a more extended memoir published the following year the same views are expressed. In 1901 Clark and Martin in a detailed report proposed the classification now used in Maryland. The Pamunkey formation was raised to the position of a group and within this two formations, the Nanjemoy and Aquia, were differentiated on both lithologic and faunal grounds. The Woodstock was relegated to the position of a substage resulting in the following divisions:

| Group | Formations or Stages | Members or Substages |
|---|---|---|
| Pamunkey | Nanjemoy | Woodstock. |
| | | Potapaco. |
| | Aquia | Paspotansa. |
| | | Piscataway. |

THE MIOCENE

The detailed classification of the Miocene, like that of the Eocene, was worked out largely during the years 1880-1905. As already pointed out, Conrad long considered what is now recognized as Miocene as the equivalent of the " Older Pliocene." Later, in 1841, he realized its true position, and here the matter rested for a long time. In 1863 Dana proposed the term " Yorktown epoch " to include the Miocene deposits of the Middle Atlantic Slope.

Heilprin, in 1880, after a careful study of fossils from the Miocene of Maryland, decided, on the basis of percentage of living forms, that these strata were of differing ages and could be divided into an " Older Period " and a " Newer Period." The latter was itself divided into the " Patuxent Group " and the " St. Mary's Group." In 1882 he presented a more complete classification for the entire Atlantic Slope as follows:

Upper Atlantic Miocene—the Carolinian Group. Represented by North and South Carolina deposits.

Middle Atlantic Miocene—the Virginia Group. Whole or most of the Virginia deposits and Maryland Newer Group.

Lower Atlantic Miocene—the Marylandian Group. The Maryland older Group and possibly the lower portion of the Virginia formation.

Darton, in 1891, referred the Miocene deposits of Maryland to one formation which he called the Chesapeake. This view was accepted by Dall and Harris in 1892.

In 1893 Harris made a report on detailed paleontological investigation along the Calvert Cliffs. He recognized there three separate faunas in ascending order, the "Plum Point fauna," the "Jones Wharf fauna," and the "St. Mary's fauna." Dall, in 1898, retained these divisions and correlated them with the Helvetian of Europe. Shattuck, in 1902, stated that three formations could be recognized each with well-defined lithologic and faunal characters. These he named the "Calvert," "Choptank," and "St. Mary's," and these three formations, united to form the "Chesapeake Group," constitute the Miocene of Maryland as at present understood.

In 1904 Clark, Shattuck, and Dall published a very detailed report on "The Miocene Deposits of Maryland," in which much additional data are given and many fossils described and illustrated.

### THE PLIOCENE (?) AND PLEISTOCENE

For a long time the surficial deposits of the Coastal Plain were, when differentiated at all, grouped together under the head "Diluvial." The earlier geologists had only a vague idea of the manner of their formation; and owing to the character of the materials, which promised little in the way of fossil evidence, almost no attempt was made to classify them. H. D. Rogers, in 1844, first used the term "post-Pliocene or Pleistocene" for these deposits of latest Tertiary age, describing under this caption the fossiliferous deposits at Wailes Bluff. Desor, eight years later, described these same deposits and attributed the origin of the large boulders found therein to the transporting agency of ice.

Very little progress was made for the next 25 years. In 1877 Wm. B. Rogers published a paper on "Gravel and Cobblestone Deposits of Virginia and the Middle States." In this the author recognized clearly the origin of the surficial deposits in glacial times through the work of streams aided by the action of ice. He also made the important observation that these deposits were laid down at a time when the land was lower and the

FIG. 1.—VIEW SHOWING REYNOLDS IRON MINE IN THE ARUNDEL FORMATION, 1 MILE SOUTH OF HANOVER.

FIG. 2.—VIEW SHOWING MASSIVE VARIEGATED CLAY OF THE PATAPSCO FORMATION, NEAR HAWKINS POINT.

headwaters of the present estuaries penetrated farther inland. He vaguely indicated the position of an old sea cliff near what is now designated the "fall line," which he made the source of many of the boulders occurring in the deposits. Chester, in 1884, working in Delaware and in eastern Maryland, also recognized an old shore line far inland from the present one and differing also from the "fall line." To these two men belongs the credit of recognizing to some extent the feature which enabled McGee, Darton, and Shattuck to work out a satisfactory classification of the surficial deposits by physiographic criteria.

The first worker, who, from the study of the surficial deposits, obtained a really philosophic grasp upon their stratigraphy, was W J McGee who, between the years 1886 and 1891, published several important papers on this subject.

In 1891 McGee, in an exhaustive memoir, discussed the Lafayette formation, since termed the Brandywine formation in the Maryland region. Three years previous he had recognized this as distinct from the later Pleistocene along the Middle Atlantic Slope and had designated it the "Appomattox" formation. In the later paper he asserted the identity of the Appomattox with the Lafayette as established by Hilgard in Mississippi in 1855 and 1856. McGee, though uncertain as to the exact age of these deposits, considers them "many times older than the earliest known Pleistocene deposits, and much newer than any other well defined formation of the coastal plain."

About this time Darton began his work on the surficial deposits, and during the next 10 years accumulated much data concerning them. He recognized an "Earlier" and a "Later" Columbia, and extended the northward limits of the Lafayette.

In 1901 Shattuck, working with improved topographic maps, recognized in the "Columbia Group" three distinct series of terraces, the Talbot, Wicomico, and Sunderland, with the Lafayette terrace at a still higher level. In 1906 he published an extensive monograph on "The Pliocene and Pleistocene Deposits of Maryland," in which the same classification—the one now employed by the Maryland Geological Survey—is retained.

The age of the Brandywine is not definitely determined and is left practically as stated by McGee.

A rather different classification of the New Jersey deposits has been developed by Salisbury. Shattuck, however, has stated that with the exception of the Brandywine, which is absent in that area, he has been able to apply his classification of the surficial deposits to the New Jersey area.

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# THE PHYSIOGRAPHY OF ANNE ARUNDEL COUNTY

BY

HOMER P. LITTLE

## Introductory

Maryland has been divided into three physiographic provinces—the Appalachian Region, the Piedmont Plateau, and the Coastal Plain; Anne Arundel County lying almost wholly within the last.

The term Coastal Plain is applied to the series of gravels, sands, and clays stretching along the Atlantic Coast from Martha's Vineyard to the Gulf. Throughout most of its extent the term also connotes the idea of deposits largely unconsolidated. Conspicuous through the middle district, at least of this coastal region, is a series of practically level plains, comprising the surficial deposits, each usually separated by a sharp offset from the one succeeding. No one driving across the country can fail to be struck by the fact that after passing across one level plain, then up a series of low choppy hills, or merely up one sharp rise, he often finds himself again on a perfectly level surface, but 15, 25, or perhaps 50 feet above the one he has just left. The geologist has found that these plains or terraces may be grouped together into a series of four members, or five if we include one now in process of formation, and he has given each a distinctive name. The lowest one—the one not yet complete—has been called the Tidal Marsh, or better, the Recent Stage; then come in order of increasing altitude and also of increasing age, the Talbot, the Wicomico, the Sunderland, and the Brandywine. The characteristics of each of these will now be discussed.

## TOPOGRAPHIC DESCRIPTION

### TOPOGRAPHIC FEATURES

#### *Tide Marshes*

Anne Arundel County is much freer from tidal marshes than are many regions of the Coastal Plain. Several of the larger rivers—the Magothy, Severn, and South River—have no marshes of large extent. There are three principal areas of tidal marshes: one, on the Patapsco River, is best developed near Brooklyn and extends to the head of tidewater; a second is found along the east margin of that area lying between Rockhole Creek and West River and known as "The Swamp"; the third and most considerable area is that along the tidal portion of the Patuxent River.

Since these marshes are partially submerged every day, and any little irregularities filled in by deposits of mud, it follows that they can show no permanent effects of erosion but will be practically flat and perfectly featureless. Theoretically, the higher terraces all possessed originally this same featureless character.

#### *The Talbot Plain*

The Talbot Plain is developed along much of the bay shore, and along the lower courses at least of nearly all the streams. The only considerable area of continuous development, however, is in the region between Rockhole Creek and South River, included in large part in the area above referred to as "The Swamp." Another typically developed area of Talbot, though not nearly so extensive as the preceding, occurs on the west shore of Curtis Creek along the main road to 1 mile west of Walnut Point. A third well-preserved fragment is found on the eastern extremity of the neck of land between Severn and Magothy rivers.

The Talbot Plain extends from sea level to about 45 feet above tide. It may be continuous with the tidal marshes below, or may be separated by a wave-cut cliff. The latter case is by far the more common. Since the Talbot Plain is the latest which has completely emerged above the sea, it has suffered but slightly from erosion. The county as a whole, however,

FIG. 1.—VIEW OF WHITE ROCKS, PATAPSCO RIVER, SHOWING SANDSTONE LEDGES OF RARITAN FORMATION.

FIG. 2.—VIEW OF GLASS SAND QUARRY IN RARITAN FORMATION, NEAR STONY POINT, SEVERN RIVER.

is so well drained that even this terrace has been generally cut into patches with the older deposits exposed between. This is clearly seen in the geological map of the region of the lower Patuxent, and of the various necks which jut out into the Patapsco. Even here, however, the valleys are so narrow and simple that in looking over the landscape these patches often present the appearance of an undissected plain.

### *The Wicomico Plain*

This terrace is not nearly so well developed in the eastern section of the county as the Talbot. It is practically absent from the border of the large Talbot area of "The Swamp." There are areas of considerable development in the region between Benfield and Glenburnie, and in the vicinity of Woodwardville. It is, however, best and most typically developed in the western extremity of the county and in the southern half, along the Patuxent.

The Wicomico Plain lies at an elevation of from 40 to 100 feet above tide, and may in the upper courses of the larger streams reach 120 feet. It is usually separated from the Talbot Plain by a scarp of about 10 feet, similar to that separating the Talbot from the Recent. This may, as in the former case, be entirely lacking in places.

The Wicomico surface is more dissected than that of the Talbot below and much less dissected than that of the Sunderland above. A glance at the map in the region of the Patuxent just referred to shows how the minor tributaries have cut through it, and much more fragmentary areas are found farther inland.

### *The Sunderland Plain*

The Sunderland Plain is typically and extensively developed throughout the southern half of Anne Arundel County (south of latitude 39°). North of here it has been largely removed, but the terraced surfaces found over large areas of the earlier formations bear witness to its presence until comparatively recent times. The only well developed Sunderland terrace of the northern part of the county is found extending from South

Baltimore to the region about Shipley and Linthicum. There are, however, numerous small patches scattered throughout the higher portions of the entire county.

The altitude of the terrace ranges all the way from 80 to 220 feet. It is almost invariably separated from the Wicomico Plain below by a pronounced scarp, often an exceedingly striking topographic feature. These scarps may be seen at almost any point in the southern part of the county, especially along the western border, but they are rarely typical in the northern part. One of the best of this latter section is to be seen a little over ½ mile south of Woodwardville where the scarp presents an abrupt rise of about 25 feet. Although the Wicomico below is well developed, the Sunderland has been largely removed, so that in all probability this scarp was formerly even more imposing than at present.

The Sunderland has been entirely removed over large areas, although the general configuration of the surface makes it certain that deposits representing this plain have been present. Even where it is preserved it often shows an undulating surface, and in the smaller remnants may be so cut up by secondary gullies and ravines that its original plain-like surface can be appreciated only by careful allowance for the modifying effects of stream erosion.

### *The Brandywine Plain*

The Brandywine Plain has been almost entirely removed by erosion from Anne Arundel County. The only fragment left in the southern half of the county is at Marriott Hill. Another small remnant is found 2 miles east of Laurel, another 2 miles east of Jessups, and still another about 1 mile west of Stony Run Station. Outside of a few other insignificant exposures, this is the whole extent of the Brandywine in the region under discussion.

The Brandywine is found at altitudes ranging from 200 to about 300 feet. In more typical areas of development the Brandywine is separated from the Sunderland by a scarp similar to that separating the other plains. Only faint traces of such a scarp can be recognized in Anne Arundel County. This is what would naturally be expected for the

Sunderland sea submerged almost the entire county, and such exposures as are found apparently projected as small islands above this sea. The case of Marriott Hill is especially clear on this point, since it is surrounded on all sides by well developed deposits of Sunderland age.

The Brandywine sea is known to have cut a scarp in the solid rock of the Piedmont Plateau, but since Anne Arundel County was everywhere submerged during this period the development of the scarp was entirely to the westward of this county.

## THE DRAINAGE OF ANNE ARUNDEL COUNTY

### *Stream Divides*

Miller[1] has observed in the region just south of Anne Arundel County that the stream divides between Patuxent River and Chesapeake Bay lie much nearer the latter, and explains this by the fact that the bay has worn away the land on that side and has thus shortened the streams flowing into it. This is true only for the extreme southern part of the region under discussion—in that area around Herring Bay which marks the northern terminus of the Calvert Cliffs. The remainder of Anne Arundel County is pierced by large tidewater estuaries which penetrate far into the heart of the county. Their numerous and active tributaries have pushed the divides well over towards the Patuxent area. In comparison with the area to the south the seaward extension of these streams has been little shortened. The relief presented to the wave action is not so pronounced, and the slopes are often protected from erosion by low sandy shores which break the force of waves, and whose imponded streams indicate constructive rather than destructive work. There are some areas where very active erosion is taking place, as in the vicinity of Hawkins, Bodkin, and Thomas points, but the above statement is in general true, especially for the area between Severn and Magothy rivers, and between South River and Herring Bay. Both of these areas are composed largely of resistant Pleistocene clay, with level surface or sloping gently towards the bay. Although the interior of the county is well-drained and its surface cor-

[1] Patuxent Folio, No. 152, U. S. Geol. Survey, Atlas of the United States.

respondingly much dissected, nevertheless the narrow divides still preserve, especially south of latitude 39°, the flat terrace aspect so helpful in working out the past physiographic history of the region.

### *Tidewater Estuaries*

Although many of the counties of Maryland are penetrated by larger tidewater estuaries, none can boast a series more strikingly beautiful than those of the Magothy, Severn, and South rivers. These streams are, indeed, commercially valuable and afford, especially in the case of the Magothy, transportation facilities by means of which many cargoes of choice fruit and vegetables find their way to the Baltimore market. They afford ideal locations for summer homes and recreation spots, and the opportunities they offer for these are being more and more appreciated. South River is as yet almost untouched, but landowners of the region are holding their property at fabulously high prices in expectance that future accessibility will bring their beautiful river into prominence. Magothy River is still the region of modest little cottages where those of moderate income may enjoy the advantages of life by the water. It is on the Severn that the greatest development has taken place during the last few years. From its mouth to its head the river is dotted with beautiful summer homes. As has been already mentioned, all these streams are largely free from marshes; they are lined throughout their course by high bluffs and are navigable by small launches to their very heads. Altogether they are ideal for the purpose for which they are being increasingly utilized.

Another series of estuaries, which are much smaller, take their value largely from their close proximity to Baltimore. These are Curtis, Rock, and Stony creeks. They are crowded throughout their length with little resorts much frequented in season.

Thus it will be seen that the estuaries have added much to the wealth of the county. Not only do they afford waterways, but they have made valuable large areas of land fronting on them, which in many cases would be almost valueless from an agricultural viewpoint.

### *The Patuxent River*

The Patuxent River, including its tributary the Big Patuxent, forms the western border of Anne Arundel County from its southwest extremity to Laurel. The Patuxent River proper divides at Priest Bridge into two streams known as the Little and Big Patuxent. The total area drained is 960 square miles. The river is of little value to the county, for its availability for water power ceases at Laurel, while navigation begins only just before it leaves the county. Along much of its course in Anne Arundel County it is skirted by swamp land. It differs from the tidewater estuaries in that it presents two distinct stream types. First, there is that type ending at Laurel in which the river has a steep gradient, runs rapidly over a rock bottom covered with boulders, and furnishes considerable water power. This is the type of stream found to the west of the fall line. After passing into the Coastal Plain at Laurel the second type is presented. The river moves sluggishly over unconsolidated sediments, develops low banks which it overflows in time of high water, and in its lower course becomes estuarine in character.

### *The Patapsco River*

The Patapsco River is similar in character to the Patuxent in that it presents in its upper course a rapid flow over a steep rocky bed, and in its lower course a slow movement over an area of gravels, sands, and clays. With its branch, Deep Run, it forms the north and northwest boundary of the county. Unlike Patuxent River, its navigable portion borders Anne Arundel County and aids greatly in putting the northeast portion of the county in touch with the Baltimore markets.

## TOPOGRAPHIC HISTORY

### *Introductory*

The surficial deposits described above—the Brandywine, Sunderland, Wicomico, and Talbot—are underlain by older sediments. These, however, have little to do with the topographic history of the county and will not be discussed. The sequence of events shown by a study of the surficial deposits—and their record is very clear—show that the sea formed each of these terraces in succession, carved out a scarp, and later retreated.

### *The Brandywine Stage*

The Brandywine is preserved in only very fragmentary patches in Anne Arundel County. Wherever these are found, even at the extreme western border, they occupy the highest points. A terrace, then, reconstructed from these areas would overlie every other formation in the county; the sea which laid down these deposits covered the whole county just as the present sea covers all the deposits to the seaward of its wave-cut cliff; therefore the scarp of this period should be sought beyond the limits of the county where in fact it is found.

After the deposition of the Brandywine sediments the region was raised, eroded, some of the deposits just laid down were removed and in many cases it appears that the streams cut through into the underlying formations. The truth of this last statement is indicated by the fact that there are many exposures in each terrace where the débris removed by the waves from the opposing cliffs is composed entirely of material belonging to these lower formations. How far to the east the land extended at this and subsequent periods of elevation it is impossible to say. After erosion had proceeded for some time the land again began to sink and the next stage was ushered in.

### *The Sunderland Stage*

As the land sank the sea once more flooded the county and gradually progressed inland, first flowing up the river valleys, later running more and more up the slopes, until finally almost the whole county was again inundated. As this sea worked its way landward it continually drove before it a wave-cut cliff which in a few cases was not pushed beyond the limits of the county. The two areas where this scarp is best preserved appear to have stood up from the Sunderland sea as islands, for they are surrounded on all sides by this sea cliff, with the older sedimentary formations exposed under the Brandywine cap. One of these areas is at Marriott Hill in the southern part of the county; the other is at the high hill 1 mile west of Severn Station. In both of these cases only a small patch of Brandywine is left, but the scarp is nevertheless strikingly clear.

At the latter locality, especially when viewed from the south, a most pronounced scarp is evident.

As in the preceding Brandywine stage, the Sunderland was brought to a close by an elevation which forced back the sea and exposed the surface of the land to the action of erosion. Some of the surficial deposits were removed, and doubtless parts of the underlying formations. Then once more subsidence occurred and the next stage began.

### *The Wicomico Stage*

The Wicomico sea offers a marked contrast to the Sunderland in its areal extent over Anne Arundel County. While the Sunderland sea found its western limit almost wholly beyond the county, the Wicomico sea penetrated westward beyond its limits in only one instance. This exception was along the Patapsco, the ancient sea having found its way up the valley of the river to beyond Relay. This is proven by tracing and connecting the remnant of the old sea cliff which, as has already been pointed out, is so strikingly developed between the Sunderland and the Wicomico. This cliff may be taken as indicating a considerable period of stability at this stage.

The reference just above to the Wicomico sea having found its way up the ancient valley of the Patapsco River brings out an interesting fact—the larger rivers of this region have occupied their present valleys ever since the uplift which terminated Brandywine time. This may easily be seen, for fragments of every terrace after the Brandywine may be found lining the banks on either side, one above the other. This means that the streams of the Brandywine epoch cut valleys with sides so deep that neither the Sunderland nor any of the succeeding inundation could completely obliterate them, with the result that after each emergence they became again the natural lines of drainage to the sea. The rivers, cutting their way through the newly formed terraces, left on their borders the fragments visible to-day.

As in the preceding stage, the Wicomico was brought to a close by an elevation during which the phenomena of erosion of the preceding eleva-

tions were repeated. Then came the sinking which ushered in the last complete cycle.

### *The Talbot Stage*

This stage differs but little from those preceding. A similar encroachment of the sea took place, although not to so pronounced a degree, and a similar sea cliff was gradually sculptured out along its margin. The lower courses of the streams were again partially filled with marine sediments and a considerable terrace was built up. This terrace, rather meagerly preserved in Anne Arundel County, may be seen in great development on the Eastern Shore, where entire counties are composed of it and have no other physiographic history.

The elevation which closed the Talbot is interesting in that it not only brought to the surface the present land area, but in addition a flat featureless plain which extended out into the bay some distance beyond the present shore line. Then, as in previous cases, was a submergence, present conditions were ushered in, and the county took on the general form which we know to-day.

### *The Recent Stage*

As in previous stages, and probably at about the same rate, erosion is now at work tearing away the surface deposits and eating into the older deposits beneath. These are being transported by the rivers to the sea, where they are spread out over the bottom and help to build up the terrace now in process of construction. The streams have attacked the Talbot deposits only slightly because of its low elevation; the erosion of the waves in forming and driving inland the modern sea-cliff has been a more active agent in removing these latest deposits. But the older terraces, raised higher and higher by each retreat of the sea, are now at the highest elevation they have ever attained and are hence being somewhat more rapidly worn away. The entire disappearance of the Brandywine terrace from the county is indeed a matter of only a short time, geologically speaking. On the other hand, it is easy to imagine that a future uplift may add still another terrace to the list and inaugurate a new Recent Stage, but this is entirely within the realm of speculation.

# THE GEOLOGY OF ANNE ARUNDEL COUNTY

BY

HOMER P. LITTLE

## Introductory

Anne Arundel County presents a nearly complete section of the Coastal Plain formations of Maryland. Two of these, the Arundel and the Magothy, find their type development within the county. The geological sequence is as follows:

- Pleistocene Period.
  - Sunderland Formation.
  - Wicomico Formation.
  - Talbot Formation.
- Pliocene (?) Period.
  - Brandywine Formation.
- Miocene Period.
  - Chesapeake Group.
    - Choptank Formation.
    - Calvert Formation.
- Eocene Period.
  - Pamunkey Group.
    - Nanjemoy Formation.
    - Aquia Formation.
- Cretaceous Period.
  - Upper Cretaceous Formations.
    - Monmouth Formation.
    - Matawan Formation.
    - Magothy Formation.
    - Raritan Formation.
  - Lower Cretaceous Formations [Potomac Group].
    - Patapsco Formation.
    - Arundel Formation.
    - Patuxent Formation.

No continuous section exposing all these formations one above the other is known, but it is confidently believed that to the seaward, where erosion

has had no chance to work, each occurs above the other in an unbroken sequence.

Although these formations, outside of the surficial deposits, are all distinguishable paleontologically and most of them lithologically, there are certain features which they possess in common. These are: (1) A strike approximately northeast and southwest. (2) A very gentle southeast dip gradually decreasing from about 90 feet per mile in the Patuxent formation to about 10 feet in the Choptank formation. (3) An increase of thickness down the dip. (4) A probable increase of dip as the old shore lines towards the Piedmont Plateau are reached, especially in the Potomac formations. (5) A prevailing unconsolidation of the deposits and consequent lack of folding and faulting. A common feature possessed by the surficial deposits is the predominance of original slope over dip. This is further explained under the discussion of the physiographic character of the Brandywine.

Although, as has been stated, the Coastal Plain forms practically the whole of Anne Arundel County, brief mention must be made of what is known as the Piedmont Plateau, since it penetrates the county at its western extremity along the bottom of the valley of Little and Big Patuxent rivers. The Piedmont Plateau is composed of very old crystalline rocks, which have been greatly metamorphosed in earth movements and subjected to many intrusions of igneous rock so that they contrast greatly with those of the Coastal Plain. Its principal interest here is that it furnished the greater part of the material which makes up the Potomac formations and that its seaward extension forms the base on which these rest. For further information, reference should be made to Volume VI of the Maryland Geological Survey under the chapter on "The Physical Features of Maryland."

The characteristics of the various Coastal Plain formations will now be discussed in detail.

## THE CRETACEOUS PERIOD

### THE POTOMAC GROUP

The Potomac group is composed essentially of gravels and bright to somber-colored clays, in which those of bright color predominate. The three formations composing the group are quite similar lithologically, but the unconformities existing between each and the paleontological variations discovered have made it certain that in spite of any lithologic similarity very different ages are represented. Fossils are, however, by no means common, and the unconformities are often not evident, due to poor exposures or obliteration by similarity of material; the line of contact drawn may therefore at times be inexact, but even if the precise limits are not always represented the real relations of the beds are shown far more truthfully than by any system which grouped them together into one formation. The three formations are undoubtedly there—there are sections where they can be clearly pointed out—and if there is difficulty in determining the exact stratigraphic position of isolated exposures except by topographic position, this is a necessary difficulty in any classification which gives due consideration to the fact that more than one formation is represented in this series of largely unfossiliferous beds.

#### *The Patuxent Formation*

The term "Patuxent formation" is derived from the Patuxent River in the upper basin of which these deposits were first differentiated as an independent formation.[1]

##### Areal Distribution

The Patuxent formation is exposed only along the extreme northwestern edge of this region, where the Patuxent and Patapsco rivers with their tributaries have cut deep valleys and penetrated to the Patuxent beds. There are no outliers and the area of outcrop is continuous.

[1] Clark and Bibbins, Jour. Geol., vol. v, 1897, pp. 479-506.

### Character of Materials

The Patuxent is prevailingly an arenaceous deposit, usually carrying a considerable amount of arkose, with local beds of gravel. At times large lenses of light to highly colored clays are developed which may resemble very greatly the variegated clays of the Patapsco formation. In the limited exposures of Anne Arundel County the arenaceous phase greatly predominates. The only good exposures occur at two large sand pits, one about 1 mile east, the other 1 mile northeast of Laurel. At the first of these, about 25 feet of arkosic sharp buff sand is exposed. White clay-balls are frequent, and at times the section is largely composed of argillaceous material in the form of white to yellow clay. Many thin fragments of iron crust brightly tinted by red hematite are present. These often form small geodes with very fragile walls. The material of the pit to the north of this one is much coarser, the sand tending towards a gravel and showing much cross bedding. The same tendency to grade into a whitish clay, especially in the lower part, is noticeable.

### Paleontologic Character

The arenaceous character of the Patuxent has been unfavorable to the preservation of most types of life. The known fauna is limited to a Unio and the remains of a fish. The flora comprises the remains of ferns, cycads and conifers.

Although conditions were in general unfavorable for fossilization, there was one type of plant life for whose preservation these conditions seem to have been most favorable. This type was the trunk of the cycad. Large numbers of these were silicified, preserving the internal structure to some degree and the exterior form with much perfection. Although these trunks have been found lying on the surface of various formations above the Patuxent, there is a strong probability that they have been reworked and that the silicification of all these trunks took place in the Patuxent beds. They have nowhere been found in place, although what was probably the exact spot where one rested in the Patuxent beds was located. These trunks are interesting in showing the former abundance

of a now living but decadent type. A locality where several fragments of cycad trunks have been found, as well as a considerable amount of silicified wood of other families of trees, is on the farm of Noah Donaldson, 1 mile cross country east of Brock Bridge.

### Strike, Dip, and Thickness

The strike of the Patuxent formation in this area is north-northeast by south-southwest, and the normal dip about 60 feet to the mile. Near the fall-line this increases perceptibly and there reaches 90 feet to the mile.

At many localities outside the county the Patuxent formation is considered to reach a thickness of 350 feet or more, while well borings point to a maximum thickness of nearly 500 feet. In Anne Arundel County the formation averages about 80 feet in thickness and probably does not exceed 100 feet.

### Stratigraphic Relations

The Patuxent formation rests on crystalline rocks. These, as will be later shown, are a continuation and an integral part of the rock composing the Piedmont Platcau. The unconformity between these two represents a time interval compared to which any lapse found in the beds above is insignificant. In this county the Patuxent formation is almost universally overlain by unconformable beds of Arundel age.

## *The Arundel Formation*

The term Arundel formation is derived from Anne Arundel County, where the deposits of this age are well developed. It was proposed by Clark and Bibbins[1] to include that series of clays lying between the Patuxent and Patapsco formations.

### Areal Distribution

In distribution the Arundel is closely related to the Patuxent formation, occurring as a fringe, usually narrow, along its eastern edge. Like the Patuxent its exposure is due to the deep trench cut by the Patuxent

[1] Clark and Bibbins, Jour. Geol., vol. v, p. 485.

and Patapsco rivers and Deep Run near the western edge of the county; it never caps the divides, so that although of considerable thickness and well developed, its areal extent is comparatively small.

Good exposures of the Arundel formation are found opposite Hanover, Howard County; at the old mines, 1 mile southwest and ⅜ of a mile south of Bridewell; and along the road, ½ mile southeast of Annapolis Junction. Good exposures are numerous throughout the area of outcrop.

### Character of Materials

The Arundel is essentially a clay formation carrying considerable quantities of iron ore. The presence of this latter makes possible most of the variations found in the otherwise rather uniform beds. When unweathered the clays are usually a dark blue-drab, containing numerous nodules or concretions of iron carbonate, often septarian in character. These are called "white" or "hone" ore by the miners. In the past this ore has been of much commercial value and is still mined to a limited extent. Masses many tons in weight have been found. A further discussion of these will be given under "Mineral Resources of the County." When weathered slightly the drab clay takes on a light pinkish-drab tone, which is very characteristic of mines or cuts where the surface has been exposed a comparatively short time. On continued exposure the carbonate alters to the hydrous oxide of limonite and the oxide hematite and the clays become a bright red, often greatly resembling the Patapsco clays above. The nodules then take on the form known to the miners as "brown" ore. The clays of the formation are very carbonaceous, and lignitic logs, much flattened, are common. Less frequently hematite and limonite have replaced the woody material, and large fragments of ferruginized logs are found, as at Reynold's iron mine. Occasionally trunks are found in an upright position with roots still in place.

Two very characteristic sections of this formation have been given in the original description of the formation.[1] They cannot be bettered and are given below:

[1] Clark and Bibbins, Jour. Geol., vol. v, pp. 487 and 480.

*Section at Reynold's Mine, Piney Run, 1 mile south of Hanover.*

| Potomac Group. | | Feet | Inches |
|---|---|---|---|
| Patapsco.... | White and light brown sand and gravel, containing crusts of iron-stone[1] | 10 | |
| | White variegated argillaceous sands, "fuller's earth," clay and paint clay with paint rock at the base. Silicified coniferous and cycadean trunks | 10 | |
| | Ferruginous ledge more or less conglomeritic.. | | 3 |
| Arundel.... | Drab-colored compact laminated clays, containing beds of lignite and bearing fern impressions; nodules, flakes and ledges of "white ore" slightly plant-bearing | 70 | |
| | Total thickness | 90 | 3 |

*Section at Timberneck on Licking Run, 1 mile southwest of Hanover*[2]

| Potomac Group. | | Feet |
|---|---|---|
| Patapsco.... | Reddish sands, somewhat gravelly, containing "pipe ore"[3] | 12 |
| | White, red, and brown sands, more or less argillaceous, containing clay pellets | 20 |
| Arundel.... | Drab-colored pyritous clays with beds of lignite; pellets, nodules, and flakes of carbonate of Iron ("white ore") | 100 |
| | White clay (in bed of Licking Run) | 5 |
| | Total thickness | 137 |

## Paleontological Character

The Arundel, though not abundantly fossiliferous, contains both plant and animal remains. These latter have played an important part in the controversies which have arisen as to the age of the Potomac group, for they include those dinosaur remains collected from the Muirkirk area in the neighboring county of Prince George's on which most of the arguments in favor of the Jurassic age of the lower Potomac beds have been based. Of the several localities in Anne Arundel County in which fossil leaves have been found the only one of any importance is Soper Hall, a

[1] Considered Raritan in original report.
[2] This section occurs just over the line in Howard County.
[3] Considered Raritan in original report.

region of abandoned iron mines, about 2 miles below Elkridge Landing on the right bank of the Patapsco, where *Sequoia ambigua* Heer and *Sphenolepsis sternbergiana* Schenk have been collected. At this same locality a few teeth and bones, probably belonging to dinosaurs, have been found.

### Strike, Dip, and Thickness

The strike of the Arundel formation is about north-northeast and south-southwest as in the preceding formation. The dip is slightly less than that of the Patuxent, being 40-50 feet to the mile. Like the Patuxent, its dip increases towards the fall-line where it reaches about 72 feet to the mile.

The thickness of the formation in Anne Arundel County cannot be exactly stated. As seen in the section at Licking Run, it reaches at least 100 feet. The maximum for the county is probably about 125 feet.

### Stratigraphic Relations

The Arundel formation overlies unconformably the Patuxent and is in turn overlain unconformably by the Patapsco.

## *The Patapsco Formation*

The term Patapsco formation[1] is derived from Patapsco River, along whose lower course beds of this age are well developed.

### Areal Distribution

The Patapsco formation is widely exposed throughout the northern half of Anne Arundel County. It dips below sea level to the east of the line of strike, passing south-southeast from Stony Creek. At first it is exposed only in the bottom of the stream valleys, but unlike the preceding formations it quickly rises to the surface and caps the divides over large areas. Very good exposures are found at Hawkins Point, the type locality; at Marley Station, on the Annapolis Short Line, and throughout Marley Neck; at the sand pits overlooking South Baltimore; and in the

[1] Clark and Bibbins, Jour. Geol., vol. v, p. 489, 1897.

FIG. 1.—VIEW OF THE MAGOTHY FORMATION AT CAPE SABLE (NORTH FERRY POINT), MAGOTHY RIVER.

FIG. 2.—VIEW SHOWING THE MATAWAN FORMATION OVERLYING THE MAGOTHY FORMATION AT ROUND BAY, SEVERN RIVER.

western part of the county in almost any of the numerous cuttings where the roads descend into the deep stream valleys of the region.

## Character of Materials

The Patapsco is a formation of very variable lithologic character in both vertical and horizontal directions. Sands grade into clays and vice versa with remarkable frequency. The great variability of the formation may be realized from the fact that a well digger reported to the writer that he found at one house, after passing through a thin covering of sand, about 40 feet of tough variegated clay, while at another house almost directly across the road and at approximately the same level he passed through 40 feet of sand without a trace of clay. Taken as a whole, however, the argillaceous materials largely predominate, and although cocoa-colored, dark-drab, or light-colored clays may be developed, the Patapsco is essentially a formation of brightly colored variegated clays, strikingly mottled with shades of red, purple, and gray. Local beds of gravel may occur, occasionally cemented to form a conglomerate, as at the contact with the Arundel near Reynold's iron mines, on Licking Run. The arenaceous phase is usually represented by a clean, sharp, light buff sand, strongly contrasted with the much iron-stained clay. In the vicinity of the clay the sand is often indurated. This may form what is known as "pipe ore" or may occur merely as thin ledges of a brown friable sandstone. At times this sandstone forms large masses of resistant rock. The sands are often very uniform and free from gravels, as in the pits overlooking South Baltimore. Near the base of the formation occurs a clay exceedingly rich in ocherous hematite, known as "paint rock."

*Section at northernmost of Rayner's sand pits, South Baltimore*

| | | Feet |
|---|---|---|
| Pleistocene. | | |
| Sunderland | Iron-stained conglomerate, strongly cemented, containing coarse and fine gravels | 3 |
| Potomac. | | |
| Patapsco | Harsh light-buff sand, very homogeneous throughout | 29 |
| | Total thickness | 32 |

*Section 1 mile south of Hawkins Point*

| | | Feet | Inches |
|---|---|---|---|
| Pleistocene. | | | |
| Talbot | Chocolate-drab sandy to very argillaceous loam, compact, with a few small well-rounded pebbles at the base | 6 | |
| Potomac. | | | |
| Patapsco | Fine harsh sand, irregularly colored yellow, orange, buff, and white. Scattered throughout, but occurring especially at the base are flat iron crusts much broken, averaging about 1 inch thick | 4 | 6 |
| | Variegated purple, pink, red, and gray massive clays | 20± | |
| | Total thickness | 30 | 6 |

## Paleontologic Character

In general, the fossils of the Patapsco formation consist of plant remains representing ferns, cycads, conifers, monocotyledons and dicotyledons. Several dicotyledons are of very primitive type. A few poorly preserved molluscan forms have been found. Anne Arundel County has contributed nothing of importance to the flora. One plant-bearing locality was discovered ¾ of a mile north of Woodwardville and ¼ of a mile west of the railroad crossing, where specifically unidentifiable cycad leaves and fragments of dicotyledons were found. The material in which they occurred was a sandy cocoa-colored to drab clay lens near the base of a thick exposure of variegated clay. A few fragments of dicotyledonous leaves were found in the blue pottery clay exposed in the cliff on the estate of Frank Hancock 1½ miles south of Hawkins Point. Leaves have also been found in a drab clay in "Kelly's Cut" on the Annapolis Short Line, just north of Wellhams. These were identified by Berry and all found to be characteristic Patapsco forms. They are:

*Acrostichopteris longipennis* Font.
*Celastrophyllum parvifolium* (Font.) Berry
*Cissites parvifolius* (Font.) Berry ?
*Nageiopsis angustifolia* Font.
*Nageiopsis zamioides* Font. ?
*Onychiopsis psilotoides* (S. and W.) Ward
*Pinus vernonensis* Ward
*Populophyllum minutum* Ward
*Populophyllum reniforme* Font. ?
*Widdringtonites ramosus* (Font.) Berry

### Strike, Dip, and Thickness

The strike of the Patapsco formation is like that of those preceding, approximately north-northeast and south-southwest. The dip is slightly less—35-40 feet per mile—increasing in the vicinity of the fall-line.

The thickness of the beds in Anne Arundel County is about 200 feet.

### Stratigraphic Relations

In this county the Patapsco rests on the Arundel formation, which it overlies unconformably. In areas where the Arundel was not deposited it rests directly on the Patuxent, or overlapping even this, may rest directly on the crystalline rocks of the Piedmont Plateau. This unconformity at the base of the Patapsco is very marked. The unconformity at the summit, on the other hand, is not easy to detect, and where the sandy phase of Raritan and Patapsco are coincident differentiation may be well nigh impossible.

## THE UPPER CRETACEOUS FORMATIONS

The Upper Cretaceous formations are well developed in Anne Arundel County. Each is separated from the succeeding formation by an unconformity.

The materials composing the Upper Cretaceous beds are very variable, and were it not for paleontological evidence it is certain that they would never have been grouped together. The lower beds represent a continuation of the conditions of the Potomac group, while the upper members—the Matawan and Monmouth—represent strictly marine conditions. Fossils, though not so numerous as in the later epochs, are far more common than in the Potomac group and are found in an identifiable condition in every formation except the Monmouth.

### *The Raritan Formation*

The Raritan formation receives its name[1] from Raritan River, New Jersey, along whose course the deposits are typically developed.

[1] Clark, W. B., Ann. Rept. State Geologist N. J. for 1892, pp. 181-186, 1893.

## Areal Distribution

The Raritan formation is widely exposed in Anne Arundel County west of the line of strike which passes southwest from 2 miles below Bodkin Point. It continually rises higher and higher, and the width of the outcrop widens until in the region about Odenton it occupies much of the surface of the country. From here west the land rises at about the same rate as the formation, so that exposures are found on the divides well towards the edge of the county, giving the Raritan a large areal extent.

By far the most satisfactory and characteristic sections are found on Severn River, especially at the pits of the Brennan Sand Company, ½ mile below Forked Creek.

## Character of Materials

The Raritan formation, because of its similarity of origin, more closely resembles lithologically the Lower than the Upper Cretaceous. Like the formations of the Potomac group, its strata vary rapidly in character both horizontally and vertically; sands pass into clays, and these in turn pass back into sands with startling rapidity. The clays are often pink in color and occasionally dark red, but this latter is looked upon as an exception. Drab, chocolate, and slate colored clays are also found. Along the Severn River white clays, sometimes stained yellowish by limonite, predominate. A pure white clay may pass horizontally within a few feet to one of a pronounced red color, or it may pass into a pure white sand. Some of the drab and chocolate clays contain leaf impressions, but the red and pink clays are apparently barren. These latter often contain pockets of dark red ocherous hematite known as "paint pots." This type of hematite deposit is very seldom found in continuous beds such as occur in the Patapsco.

The sands of the Raritan are medium to coarse grained and angular, and predominatingly buff in color. As in the case of the clays, however, there is an unusual development of a pure white phase on the Severn River. It was this which suggested to Uhler the term Albirupean, a name which

in this area is nearly coincident with Raritan. These sands are by no means confined to the Severn, but are most typically and extensively developed there. They are often consolidated by a siliceous cement into an exceedingly hard sandstone which has been to some extent used for building purposes. It often stands out in the form of great isolated boulders. A group of such boulders located ½ mile east of Elvaton is one of the most striking examples of consolidated rock in the Coastal Plain of Maryland. A brown, compact sandstone cemented by iron also occurs. This often contains many small angular fragments of quartz which are quite characteristic, appearing much as though shattered by the blow of a hammer and then scattered at random through the sandy material.

Besides clay and sand, gravel is often found consisting of clean subangular quartz or quartzite pebbles. Occasionally these are cemented by iron into conglomerates. Although the gravel as a rule appears to occur disseminated throughout the material of the formation rather than as distinct gravel bands, it may become concentrated at the surface as a continuous sheet due to the selective agency of erosion. This gravel then becomes extremely troublesome to separate from the surficial deposits of the Pleistocene, and no criterion to cover all cases can be found. The frequent thinness of these deposits, which occur usually only as a veneer, their cleanness, their rather uniform character, and their general freedom from débris of igneous rocks, are of assistance, and any or all of these taken in conjunction with the topography and stratigraphic relations will serve as a rule to differentiate the formations with considerable certainty.

Of the subordinate constituents of the Raritan formation, pyrite and lignite are the chief. These two are found in great abundance at the base of the low Raritan cliffs just south of Bodkin Point. Here the pyrite has filled in cavities in the decayed wood and partially replaced it. Very handsome specimens of the two may be obtained here. Large lignitized trunks, much flattened, also occur. Amber in small quantities has been found in the drab clays on the Severn River.

Numerous good sections are exposed along the Severn River; otherwise they are not common. The most complete section was obtained at the Brennan Sand Company's pit. This, with others, is given below:

*Composite section at Brennan Sand Company's pit, Severn River*

| | | Feet | Inches |
|---|---|---|---|
| Upper Cretaceous. | | | |
| Magothy.... | Small pebbles (⅛ inch) cemented with sand... | 2 | |
| | Coarse sand | 1 | 6 |
| Raritan..... | Brick-red and gray mottled clay | 16 | |
| | Tough, plastic, greenish-black clay | 5 | |
| | Red, hematitic clay, lithified, slightly sandy... | | 1 |
| | Light snuff-colored, plastic clay, lower 2 feet showing alternating bands of pink and snuff, varying horizontally to a pure white pottery clay | 6 | |
| | White sand | 3 | |
| | Light gray clay, with knife edges of white sand | 3 | |
| | White glass sand, medium coarse, with some arkose | 10 | |
| | These last two members have been shown by borings to continue downwards for 77 feet, the upper 30 feet of this being glass sand. | | |
| | Total thickness | 45 | 7 |

*Section ½ mile below Forked Creek, Severn River*

| | | |
|---|---|---|
| Upper Cretaceous. | | |
| Raritan..... | Loose yellow sand and white compact sand, alternating | 10 |
| | White massive cross-bedded sand | 10 |

The proportions of these two is very variable. At the highest point of the cliff the section is as follows:

| | | Feet |
|---|---|---|
| Raritan..... | Very plastic grayish-white clay, with occasional patches of bright red clay | 10 |
| | Massive white sand | 12 |

*Section at Clark's sand pit, 1 mile south of Severn Station*

| | | |
|---|---|---|
| Upper Cretaceous. | | |
| Raritan..... | Cross-bedded buff sands with occasional balls or thin lenses of grayish clay | 25 |

## Paleontologic Character

In various localities outside of Anne Arundel County the Raritan contains abundant and well preserved plant remains, dicotyledons predominating. These occur usually in drab clay, never in the pink or red. Occasionally leaves are found in slabs of very hematitic sandstone. Within the county under discussion fossils are very rare, and identifiable species

are known from only two localities. E. W. Berry has furnished the following memorandum which constitutes the flora so far as known.

I. Riverside Brick Company, Severn River (present site of Brennan Sand Company).
*Aspidiophyllum trilobatum* Lesq.
II. Severn Run, near Benfield.
*Podozamites marginatus* Heer
*Sassafras* cf. *acutilobum* Lesq.
*Aralia* sp.

No marine fauna is known in Anne Arundel County, nor have any vertebrate remains been found.

### Strike, Dip, and Thickness

The strike of the Raritan formation is approximately northeast and southwest. The dip is 35 feet per mile, which is the greatest of any of the formations above the Potomac group. The thickness of the formation within the county is a little over 100 feet. This increases considerably down the dip.

### Stratigraphic Relations

The Raritan formation is separated from the Patapsco by an unconformity which, however, may be very difficult of identification due to similarity of materials and to the very pronounced local unconformities occurring within both formations. The line between the Raritan and the Magothy formation is usually very clearly differentiated, although here also occasional similarities of material, especially of sands, may confuse the observer in an exposure of limited extent.

## *The Magothy Formation*

The formational term "Magothy" was introduced by Darton[1] in 1893 for certain transitional deposits occurring above the Raritan and below the Matawan, especially well developed on the Magothy River. At first it was thought by some to represent merely a phase of the Raritan, but it has now been generally accepted as a term of coordinate value with Matawan, Monmouth, and the other Upper Cretaceous formations.

[1] Darton, N. H., Amer. Jour. Sci., 2d ser. vol. xiv, pp. 407-419, 1893.

## Areal Distribution

The Magothy formation is well developed along the middle course of the Magothy River on its north bank, but is exposed only to a slight extent on the south side, due to the low character of the shore, which is covered by deposits of Talbot age. The deposits at Cape Sable on this river—or North Ferry Point, as the later maps designate it—have long been known in the literature, and many references to them appeared long before their place in the geologic column was even approximately known. The formation is equally well exposed on the Severn River in the region of Round Bay. Small exposures of typical Magothy, though isolated, are found on the bay shore a little over 1 mile below Bodkin Point, at the Forks of the Patuxent, on the Washington, Baltimore and Annapolis Electric Railroad, about 1 mile below Naval Academy Junction, and on the same line ¼ of a mile south of Conway Station. Various other areas have been mapped as Magothy, due to their position and relation to other beds which, considered lithologically alone, might with equal appropriateness have been placed in either the Raritan or the Pleistocene.

## Character of Materials

The Magothy is a formation of varied lithologic character, comprising sands and clays and occasional conglomerates which change with considerable rapidity both horizontally and vertically. Where the clays predominate an exceedingly characteristic mode of occurrence is in the form of well developed laminae, which vary from little thicker than paper to an inch or more. The interspaces between the laminae are filled with white mica and fine white sugary sand spread over the clay surface as a thin film about the thickness of one of the grains of sand. The clays themselves may be black or light chocolate drab with all intermediate stages, and are free from mica.

The sands where more largely developed may be fine and sugary, medium grained, or very coarse. The first and last of these types when present will usually serve to differentiate the formation. The fine snow-white sugary sand, often with fine particles of white mica, occurs in little pockets and often serves to give a clue to the presence of the formation

when all other means of identification are lacking. It is rarely that any other formation of the county shows this type of material. The coarse sand also is very characteristic. This sand occurs in translucent to transparent grains about the size of BB shot, often showing an unusual proportion of blue or amethystine quartz. The sands, especially those of medium grain, are often loosely indurated and form a brown sandstone quite characteristic. On weathered or overgrown slopes this sandstone, projecting as a ledge, should serve to put the geologist on the lookout for other indications of the presence of the Magothy formation.

Lignite and pyrite are abundant, and in certain localities compose an essential part of the strata. At North Ferry Point the pyrite occurs in a compact ledge sufficient in amount to have been in the past commercially valuable. In the same section lignite is abundant and several varieties of amber have also been described from there. On the west bank of Valentine Creek, Severn River, are found very lignitic black clays. So far as known the Magothy of Anne Arundel County contains no glauconite.

*Section at Laboratory Point, Cape Sable, Magothy River*

| | | Feet | Inches |
|---|---|---|---|
| Matawan | Fine greenish glauconitic, yellow mottled sand. Sharp stratigraphic break at base | 10 | |
| Magothy | Loose and very coarse white sand interstratified with brown sand, containing small quartz pebbles, locally lignitic, indurated, and more or less cross-bedded | 2 | 6 |
| | Light blue clay (local) | | 2 |
| | Fine white lignitic sand, with ferruginous crusts, locally indurated, friable | 14 | |
| | Black laminated clays interstratified with thin lamellae of white pyritiferous sand | | 6 |
| | Compact yellow sand with amber | 1 | |
| | Lamellum of comminuted lignitized stems and leaves, crusts of pyrite, pellets of amber, alternating with black laminated clays | | 16 |
| | Black, massive, earthy lignite, very compact, with rods, flakes, and ledges of pyrite and pyritized wood, becoming more pyritiferous towards base. Formerly utilized by the Troost Alum Works | 4 | |
| Raritan | Tough, blotched, pinkish clay underlain by white, very compact sand (at low tide) | | 5 |
| | Total thickness | 33 | 11 |

The following section illustrates some of the points brought out in the discussion of the "character of materials."

*Section on west shore of Valentine Creek, Severn River*

| | | Feet | Inches |
|---|---|---|---|
| Magothy.... | Black, laminated clay, breaking like shale, with much flattened lignitized stems. Many lumps of pyrite occur whose decomposition gives the whole shaly mass a sulphurous odor like that of a coal mine | 6 | 8 |
| | Coarse orange, yellow, and white sand, apparently capped by about 1 foot of iron conglomerate | 11 | |
| | Total thickness | 17 | 8 |

*Section at Little Round Bay, Severn River, ⅞ of a mile west of Long Point*

| | | Feet | Inches |
|---|---|---|---|
| Magothy.... | Light chocolate-drab sandy clay, very compact, with many small pebbles towards the base. Leaf fragments in the more argillaceous portions | 12 | |
| | Iron crusts | | ½ |
| | Very coarse angular quartz sand, grains averaging almost ⅛ of an inch in diameter; a large proportion of blue and amethystine grains | 2 | |
| | Unexposed | 10 | |
| | Total thickness | 24 | ½ |

*Section ⅞ of a mile northwest of North Ferry Point, Magothy River*

| | | | |
|---|---|---|---|
| Upper Cretaceous. | | | |
| Magothy.... | Bright buff sand, lower 2 feet quite coarse, sometimes indurated | 6 | |
| | Black lignitic clay, alumiferous water. Marked undulating unconformity at the base | 8 | |
| Raritan..... | White clay ("fuller's earth") grading downwards into next member | 4 | |
| | Red clay | 2 | |
| | Total thickness | 20 | |

## Paleontologic Character

Although invertebrates have been found in the Magothy formation to the north, especially in New Jersey, the only organic remains known from

this formation in Anne Arundel County are those of plants. Amber is quite common. In Upper Cretaceous deposits to the north this is known to have been secreted by a species of pine. Lignitized stems of trees are common. At certain localities quite perfect leaf impressions are found. The following list of plants from the chocolate-drab clays at Round Bay has been identified by Berry:[1]

*Andromeda Cookii* Berry
*Andromeda Novæ-Cæsareæ* Hollick
*Andromeda parlatorii* Heer
*Cinnamomum Newberryi* Berry
*Eucalyptus Geinitzi* (Heer) Heer
*Eucalyptus latifolia* Hollick
*Sabalites magothiensis* Berry
*Laurophyllum elegans* Hollick
*Laurus plutonia* Heer
*Laurus proteæfolia* Lesq.
*Moriconia americana* Berry
*Nelumbo primæva* Berry
*Quercus morrisoniana* Lesq.
*Quercus severnensis* Berry
*Rhamnites apiculatus* Lesq.
*Sequoia ambigua* Heer
*Sequoia Reichenbachii* (Gein.) Heer
*Widdringtonites Reichii* (Ettings.) Heer

## Strike, Dip, and Thickness

Very good opportunity for observing the strike of the Magothy formation is offered at Round Bay on Severn River. The points at which the Magothy dips beneath the water on each bank are accurately known and the distance between these points—2 miles—is sufficient to give a good measurement. The result found is a strike of N. 44° E. The strike varies farther north, swinging more to the east on the Magothy River.

The dip of the formation is about 30 feet to the mile. On the Severn the distance of its exposure along the dip is about 1 mile, giving a thickness there of 30 feet. This increases rapidly towards the Magothy River, where it is about twice as much. This fact may be sufficient to explain the increased eastward trend of the strike just referred to.

[1] Berry, E. W., Bull. Torrey Botanical Club, vol. xxxvii, pp. 10-29, 1910.

### Stratigraphic Relations

The Magothy is separated from the Raritan by one of the most conspicuous unconformities of the Coastal Plain. The Magothy, however, often contains sands identical in appearance with sands occurring in the Raritan and this, combined with the fact that both formations show numerous local unconformities, may make it very difficult to draw the line between them. But whenever the Magothy dark laminated clays rest upon the irregular white or pink clay surface of the Raritan, the unconformity is striking. Such a section, $\frac{1}{8}$ of a mile northwest of North Ferry Point on the Magothy River, has already been given. Sections of the first type are found just east of Cedar Point.

A less marked unconformity separates the Magothy from the Matawan above, but there usually is little trouble in drawing the line between the two, due to the practical absence of glauconite and mica in the Magothy of this county and the presence of both in the Matawan.

## *The Matawan Formation*

The term Matawan formation[1] is derived from Matawan Creek, a tributary of Raritan Bay, New Jersey, near which characteristic deposits of this age are well developed.

### Areal Distribution

The Matawan formation is typically developed along the lower courses of Magothy and Severn rivers. It is also found in force in that area bounded roughly by Gotts, Crownsville, Chesterfield, St. Stephen's Church, and Millersville. In the more eastern part of this section the exposures are found near the heads of the deep ravines which enter the main streams. Farther west they rise to the surface and cap the hills. One of the most accessible exposures, also a fossiliferous one and very typical, is found in the railroad cutting $\frac{3}{4}$ of a mile southeast of Millersville Station.

[1] Clark, W. B., Jour. Geol., vol. ii, pp. 163-164, 1894.

## Character of Materials

The Matawan contrasts greatly with the preceding formation in that it is, when unweathered, very uniform in character. It consists from top to bottom of a black sandy clay, with mica and glauconite. These last vary in abundance, but are seldom absent. The glauconite may be disseminated throughout, or may be somewhat localized in pockets. This latter case, however, is usually noticed after weathering has affected the beds.

When affected by weathering various changes take place, usually producing a gradual change from the typical greenish-black of the formation to a mealy-buff sandy clay. This latter is sometimes indurated, but not so frequently as are the more glauconitic formations above. A very instructive section showing on a small scale various stages in weathering was found in a pit beside the railroad tracks at Round Bay Station. This section is as follows:

*Section at Round Bay Station*

| | | Feet | Inches |
|---|---|---|---|
| Matawan | Dark buff, argillaceous, sandy loam, grading into member below | | 15 |
| | Light brown sandy clay, somewhat glauconitic, grading into member below | 2 | |
| | Green sandy, micaceous, glauconitic clay, grading into member below | | 15 |
| | The same, with ill-defined pockets of chocolate-drab clay and irregular streaks of red-brown argillaceous sand, with considerable glauconite, grading into member below | 1 | 6 |
| | Chocolate-drab sandy clay with red glauconite, grading into member below | 4 | |
| | Black laminated clay, with sulphur-colored streaks, glauconitic, slightly micaceous | 2 | |
| | Limonitic iron crust | | 1 |
| Magothy | Chocolate, yellow, and orange sand | | 6 |
| | Very light buff, fluffy sand, drying to a gray, with small decayed lignitic fragments and small pockets of chocolate argillaceous sand, exposed | 2 | |
| | Total thickness | 14 | 4 |

When exposed on the surface for some time the glauconite may largely disappear, the clay may largely wash away, and only a fine buff sand be

left, difficult to differentiate. As a whole, however, the characters of the formation are very persistent, and even after extended weathering present certain well defined characteristics, appearing either as a sandy clay mottled green and yellow or merely orange-yellow, or as a shaly light cocoa-colored sandy clay in which careful search often reveals pelecypods, gastropods, and cephalopods.

In addition to the above-mentioned features the Matawan shows quite commonly large log-like or oval concretions of clay ironstone, also very characteristic. They weather in concentric layers and often persist after all other characteristics of the formation have disappeared. Since no similar concretions are known in other Upper Cretaceous formations of the county, they are often of great aid in identifying problematic exposures. A few localities where these concretions may be found are: On the south side of Dutch Ship Island, Magothy River, near the top of the 20-foot cliff where there are some roughly oval concretions about 2 feet by 2 by 1. These are in fresh material. A series in much-weathered and otherwise indefinite material occurs in a shallow cutting in the main road just 1½ miles west of Long Point, Severn River. Another locality, and one where they, as well as the rest of the formation are superbly developed, is in the deep ravine near the house of Mr. Carr. 1¼ miles southwest of Crownsville.

Lignite and pyrite are also found in the Matawan, and much less frequently, fragments of amber.

*Section 2/10 of a mile east of wharf, Round Bay, Severn River*

| Upper Cretaceous. | | Feet | Inches |
|---|---|---|---|
| Matawan | Green sandy clay with brown and yellow sand | 6 | |
| | Chocolate-colored sandy clay, weathered on surface to buff and yellow, grading into member below | 6 | |
| | Black sandy glauconitic and micaceous clay, massive | 12 | |
| | Iron crust | | 2-3 |
| Magothy | Very coarse sand, angular and cross-bedded, with considerable lignite | 6 | |
| | Total thickness | 30 | 2-3 |

## Paleontologic Character

The Matawan of Anne Arundel County is rather fossiliferous, but the material as a whole is poorly preserved and hard to obtain. No remains, outside of *Exogyra* and *Anomia,* retaining the shell have been found, and both of these were too decayed to show the surface markings satisfactorily. The shells have at times been imperfectly replaced by pyrite. Anthozoa, Echinodermata, Pelecypoda, Gastropoda, Cephalopoda, and Vertebrata are all represented. One of the forms best preserved and found at almost every locality where collections were made is *Veniella conradi* (Morton). Both valves often occur united and are very easily recognized. An interesting find was Teredo-bored wood ½ mile southwest of Ulmstead Point. The best localities found for collecting were at the point just mentioned, and at the base of the high cliff of Gibson Island, both on Magothy River; also ½ mile north of Arnold Point, Severn River, and at the railroad cut ¾ of a mile southeast of Millersville.

## Strike, Dip, and Thickness

The strike of the Matawan is approximately northeast and southwest. The dip is about 25 feet to the mile. The formation attains a thickness of 60 feet southwest of Crownsville. The average is probably a little less than 50 feet.

## Stratigraphic Relations

The Matawan is unconformable with the Magothy below and with the Monmouth above. It is differentiated from the latter by the greater amount of argillaceous matter it contains, its lesser content of glauconite, and by its fossil content. Since, however, the Monmouth of Anne Arundel County is unfossiliferous, and since the transition from one formation to the other is gradual, it is not usually possible to designate the exact line of contact, although there is no difficulty in observing within a very few feet the passage from one formation to the other.

### *The Monmouth Formation*

The name Monmouth as applied here is derived from Monmouth County, New Jersey, where deposits characteristic of this formation are well developed. The name was proposed by W. B. Clark[1] in 1897 for those deposits included in the Navesink and Red Bank formations.

#### Areal Distribution

The Monmouth is closely related to the Matawan in areal distribution. It is exposed along Severn River, and caps Gibson Island on the Magothy River. Especially good exposures of Monmouth, with the underlying Matawan, are found in the road cuttings where the road from Chesterfield descends to Bacon Ridge Branch on the east and Tarman's Branch on the west.

#### Character of Materials

As already pointed out, the Monmouth differs quite decidedly from the Matawan in the large decrease of argillaceous material and the decided increase of glauconite. The formation is then, as might be expected, looser textured than the Matawan except where it becomes indurated. The glauconite may at times be quite fresh and color the formation a dark green, but usually in the more accessible exposures it is either blackened by weathering, or has been largely dissolved and redeposited in irregular bands as a cement for the sand which becomes a rich red brown. These bands may form a complex anastomosing structure which, however, is developed to a greater extent in the Eocene. Numerous concretions, very characteristic of the Monmouth and much less so of the Eocene, occur. They are what from their general structure and appearance might be called "bomb" concretions; when not intergrown they are very nearly spherical and consist of an outer layer of loosely-cemented sand, stained yellow by limonite, grading gradually into a layer of compact, almost pure brownish limonite, the two being together about an inch thick. The whole forms a globular body varying much in size but averaging about

[1] Clark, Bull. Geol. Soc. Amer., vol. viii, pp. 315-358, 1897.

FIG. 1.—VIEW SHOWING CLIFFS OF DIATOMACEOUS EARTH OF THE CALVERT FORMATION AT FAIRHAVEN.

FIG. 2.—VIEW SHOWING THE CONTACT OF THE AQUIA AND NANJEMOY FORMATIONS IN VALLEY OF BEARD CREEK.

6 inches in diameter. This shell when broken open is found to contain comparatively fresh glauconitic sand, doubtless due to its preservation from the action of the weather by the dense protecting layer of limonite. These concretions occur in large number in a road cutting a little over ¾ of a mile east of Chesterfield.

The general appearance of an exposure of Monmouth in this county is as a bank of rather homogeneous sand more or less mottled red brown and gray. A rather generalized section, not all exposed in one vertical succession, is found in a road cutting just west of Waterbury Station, and is as follows:

| | | Feet |
|---|---|---|
| Miocene | Buff loose sand, overlying impure diatomaceous earth | 6 |
| Aquia | Brown argillaceous micaceous sandy loam, grading into member below | 7 |
| | Greensand, with a few small pebbles | 2 |
| | Greensand, mostly weathered a rich brown, often indurated especially towards base, carrying many casts of *Ostrea compressirostra* | 3 |
| Monmouth | Similar greensand, not so rich a brown, unfossiliferous | 8± |
| Matawan | Mottled sandy clay with occasional poor fossil casts | 5 |
| | Total thickness | 31 |

## Paleontologic Character

No fossils have been found in the Monmouth within Anne Arundel County. In the adjoining county of Prince George's they are exceedingly abundant and at certain localities excellently preserved.

## Strike, Dip, and Thickness

The strike of the Monmouth formation is approximately northeast and southwest, and the dip about 25 feet per mile towards the southeast. The thickness of the formation is variable, 50 feet is the maximum, and it thins to the northwest until near Waterbury it apparently is little over 10 feet.

### Stratigraphic Relations

The Monmouth formation overlies the Matawan unconformably and is in this county overlain unconformably by the Eocene. As has been pointed out, the separation from the Matawan below is readily accomplished, but the drawing of the contact with the Eocene above is often attended with much uncertainty due to the great similarity of materials. This phase of the subject will be discussed more at length in considering the relations of the Eocene to the underlying beds.

## THE EOCENE FORMATIONS

### THE PAMUNKEY GROUP

### *The Aquia Formation*

The Aquia formation receives its name from Aquia Creek, a stream emptying into the Potomac River on the Virginia side. The name was proposed by W. B. Clark[1] in 1895.

### Areal Distribution

The Aquia formation is exposed over large areas in Anne Arundel County. It outcrops, usually in a weathered state, from 1 mile below the head of South River to its mouth. Perhaps the most striking exposure on the river is at the mouth of Broad Creek on the west bank. Other fine exposures are to be seen in the road cuttings near the Annapolis Waterworks, where the road descends abruptly to cross the headwaters of Broad Creek. But the most striking exposures of all are to be found in the high bluffs of the Severn, beginning opposite Annapolis and extending up the river for several miles. Here almost vertical cliffs rise in places to a height of 100 feet. On the higher levels of the neck between Magothy and Severn rivers is shown an almost continuous exposure of Aquia, terrace-like in form, due probably to the recent removal of the surficial deposits. Similar areas are found extending much of the way from Waterbury to several miles south of Crownsville. The Aquia also forms

[1] Clark, W. B., Johns Hopkins Univ. Circ., vol. xv, p. 3.

an almost continuous fringe along the Patuxent River from Governor Bridge to Hills Bridge. The most western exposure of Eocene, shown to be such by its fossils, is on the hill just east of Waterbury. An exposure still farther west, whose general relations indicate its Eocene age, is found on the high isolated hill 1 mile east of Conaways.

### Character of Materials

The Aquia presents when unweathered, a rather uniform, massive bed of glauconitic sand, often slightly micaceous. The general color effect is either a light blue or dark green, almost black at times, dependent on the amount of glauconite. Physically the formation presents a rather dense compact mass, often eroding into steep-sided ravines.

In Anne Arundel County, however, this is not the typical manner of development. Here it has been subjected to more or less weathering, which either has altered the glauconite only slightly, merely rendering the beds less compact and coloring them brown, sometimes giving a mottled pepper and salt effect; in other cases much of the glauconite has been dissolved and then redeposited, forming layers of brown iron-cemented sandstone. At times a silica-cemented sandstone is formed which is so far as noted always fossiliferous. It occurs as a gray, hard sandstone flecked with grains of fresh glauconite. Characteristic developments are found in the vicinity of Crownsville, especially in the hills just to the east of the station. The brown sandstone may occur in the form of massive ledges, but a more characteristic type is found in the form of an intricate network of anastomosing or tubular crusts, enclosing masses of loose orange, yellow, or red-brown sands. Erosion wears away the loose sands and leaves the crusts projecting several inches from the cliff. This is a purely surficial phenomenon and bears no primary relation to the strata, but it is, nevertheless, a striking sight and makes a greater impression than the more important factor now to be mentioned, namely, the presence of considerable marl in the beds as contrasted to the Monmouth below. The marl is not conspicuous, but on close examination it will be seen in many places that the sands are full of fragments of carbonate of lime

which occasionally is sufficiently preserved to show that it is the product of disintegration of shells. These, however, have usually disappeared, and in the loose sands not even the casts remain, so that generally only a fine calcareous dust testifies to the former presence of an abundant molluscan fauna.

## Paleontologic Character

Evidences are found almost everywhere that the beds of the Aquia formation have been in the past densely packed with the remains of an abundant molluscan life. Careful search will usually reveal either the casts of fossils or the witness of their former presence in the marly character of the materials. Even in banks of the most weathered sands casts are often found. It is, however, the exception to find the shells preserved. Some of the more accessible localities where the casts are plentiful are in the indurated sandstone at the mouth of Broad Creek, South River; in the high bluff opposite Horseshoe Point on the Severn; and in the road cutting opposite the entrance to Annapolis Water Works. In the road cutting just east of Waterbury is a ledge of brown sandstone containing many casts of *Ostrea compressirostra.* A very accessible locality is at the spur tracks of the Annapolis Short Line just across Dorsey's Creek from Annapolis, where many species may be found in the fragments of brown sandstone which lie scattered on the surface.

There are four species that are especially persistent at almost all localities and very easily recognized, so that it seems worth while to mention them by name. These are:

*Dosiniopsis lenticularis* (Rogers)
*Glycymeris idoneus* (Conrad)
*Ostrea compressirostra* Say
*Venericardia planicosta* var. *regia* Say

The recognition of any one of these species is very good evidence of the presence of Eocene strata. These, with all others most likely to be found, are figured and described in the Eocene volume of the Maryland Geological Survey.

*Section on north bank of Severn River, 1 mile above railroad bridge*

| | Feet |
|---|---|
| Pleistocene. | |
| Sand and loam | 5 |
| Eocene. | |
| Aquia (Piscataway)..Coarse red, glauconitic sand, partially indurated, with *Ostrea compressirostra*, *Cucullæa gigantea*, *Meretrix ovata* var *pyga*, *Turritella mortoni*, etc. | 20 |
| Red glauconitic sand and talus | 50 |
| Total thickness | 75 |

A similar section, but containing two fossiliferous layers separated by about 10 feet of barren glauconitic sand was observed by the writer ½ mile below the railroad bridge on the same side of the river.

The section[1] at the mouth of Broad Creek, South River, already referred to is as follows:

| | Feet |
|---|---|
| Eocene. | |
| Aquia (Piscataway)..Ferruginous sandstone full of casts of *Turritella mortoni*, *Venericardia plancosta* var. *regia*, *Crassatelites alæformis*, etc. | 10 |
| Coarse oxidized greensand, with occasional casts of *Venericardia planicosta* var. *regia* | 24 |
| Talus | 24 |
| Total thickness | 58 |

## Strike, Dip, and Thickness

The strike of the Aquia formation is approximately northeast-southwest. The dip is slight, only about 12½ feet per mile to the southeast. The thickness is about 100 feet, though it apparently thins considerably towards the northwest, as shown in the region of Waterbury.

## Stratigraphic Relations

In Anne Arundel County the Aquia is normally overlain conformably by the Nanjemoy. To the northwest, however, the Nanjemoy is either lacking or incapable of differentiation, and the Aquia is regarded as being

[1] Md. Geol. Survey, Eocene, p. 73.

overlain unconformably by the Miocene. The unconformity is plainly shown in the following section ½ mile south of where the road from the town of South River crosses Muddy Creek.

| | | Feet | Inches |
|---|---|---|---|
| Miocene. | | | |
| Calvert..... | Sandy loam and yellow and green, very fine sand<br>Irregular contact, thin iron crust. | 8 | |
| Eocene. | | | |
| Aquia..... | Unusually black greensand with irregular streaks of sulphurous looking limonite..... | 5 | 6 |
| | Total thickness ..... | 13 | 6 |

A rather similar section may be seen in the road about ¼ of a mile south of Crownsville, where ash-colored diatomaceous earth rests upon glauconitic sand.

The formation rests unconformably throughout on the Monmouth. Whether or not this is true has been a disputed point, because of the occurrence opposite Annapolis of *Terebratula harlani* Morton. This species has been long regarded as a type fossil of the Raritan—the Upper Cretaceous formation immediately overlying the Monmouth—and hence when this occurrence was discovered the Raritan age of these beds was at once inferred. When, however, Bagg in 1898 found *Terebratula harlani* associated with Eocene fossils near Leeland[1] in the adjoining county of Prince George's, the occurrence of Raritan strata on the Severn became a matter of uncertainty. Three explanations are possible—either Raritan beds are present, though unattested, except by these isolated forms; or *Terebratula harlani* lived on into the Eocene, a possibility not inviting to those relying on it as a type fossil; or lastly, these forms have been mechanically derived from reworked Cretaceous sediments. With the idea of throwing some light on this problem, Mr. Berry and the writer visited the locality mentioned by Bagg and made a careful collection. A ledge with many perfectly preserved specimens of the *Terebratula* in question was found. The specimens are large, often attaining a height of 80 mm. and show the tendencies to variation mentioned by Schuchert[2]—

[1] Bagg, R. M. Jr., Amer. Geol., vol. xxii, p. 370.
[2] Schuchert, Chas., Md. Geol. Survey, Eocene, p. 204.

a tendency for the shell to become a little wider than the type with loss of lobation, and also to widen the area on each side of the crural processes. No indication whatever of reworking was found in the field, and all who have examined the specimens in the office agree that they are doubtless found in place. That they occur in undoubted Eocene strata the following list of intimately associated forms, identified by Mr. Berry, shows conclusively:

*Meretrix subimpressa* Conrad
*Meretrix ovata* var. *pyga* Conrad
*Leda cliftonensis* Clark and Martin
*Dosiniopsis lenticularis* (Rogers)
*Lunatia marylandica* Conrad
*Crassatelites alæformis* (Conrad)
*Cucullæa gigantea* Conrad (young and adults)
*Turritella mortoni* Conrad
*Ostrea compressirostra* Say
*Venericardia planicosta* var. *regia* Conrad (young forms)
*Protocardia lenis* Conrad

The conclusion reached, then, is that *Terebratula harlani* lived on into Eocene time, with the recognition of the fact that close study may make it necessary to create for the later form a varietal name.

This of course does not settle conclusively the age of the horizon opposite Annapolis, for there no associated Eocene fauna is found. However, it does make it possible to place these beds within the Eocene—where their position would doubtless naturally throw them—without the assumption that the contained forms are reworked. Furthermore, Bryozoans collected at a horizon approximately the same as that in which the *Terebratula* occurs and only a few yards away, are pronounced by R. S. Bassler to be of an Eocene type, though not specifically identifiable.

## Subdivisions

Two members or substages have been recognized in the Aquia, the Piscataway below and the Paspotansa above. Each is characterized by its own group of fossils.

The Piscataway member receives its name from Piscataway Creek, which empties into the Potomac River on the Maryland side about 10

miles below Washington. It is characterized "by greensands and greensand marls, the lower beds often quite argillaceous. Two well marked and rather persistent layers of indurated marl characterize the upper beds in the Potomac region."[1] The member generally exceeds 50 feet in thickness and composes Zones 1-7 of the Maryland Eocene.

The Paspotansa member, so-called from Paspotansa Creek, which enters the Potomac River from the Virginia side, is composed of a thick bed of greensand overlain by thick-bedded indurated layers of greensand marl. It is generally somewhat under 50 feet in thickness and composes Zones 8 and 9 of the Maryland Eocene.

### *The Nanjemoy Formation*

The Nanjemoy formation derives its name from Nanjemoy Creek, one of the Maryland tributaries of the Potomac River. The term was proposed by Clark and Martin[2] in 1901.

#### Areal Distribution

The areal distribution of the Nanjemoy formation is much more limited than of the Aquia. It is exposed in the stream beds along the Patuxent River from Lyons Creek to about 2 miles north of Hills Bridge, and extends as a disconnected band in a northeast direction to within about 1 mile of South River. Isolated exposures are found beyond the river in the hill 1 mile north of Beards Point and also at Thomas Point near the mouth of the river.

#### Character of Materials

The materials composing the Nanjemoy formation are in general similar to those of the Aquia, but they are more argillaceous, less marly, and at times quite gypseous. The argillaceous character is at times very prominent, especially at the base of the formation, where it may develop into a pure pink clay called the "Marlboro clay" from its type occurrence

[1] Md. Geol. Survey, Eocene, p. 60.
[2] Clark and Martin, Md. Geol. Survey, Eocene, p. 64.

at Upper Marlboro just beyond the Patuxent River in Prince George's County. Excellent exposures of this phase of the formation are found in Anne Arundel County, 2 miles east of Davidsonville, where the road crosses the headwaters of Beards Creek.

*Section 2 miles east of Davidsonville*[1]

| Eocene. | | Feet |
|---|---|---|
| Nanjemoy | Argillaceous, green-gray glauconitic sands, Marlboro pink clay | 10-15 |
| Aquia | Very fresh green-gray glauconitic sand uniform throughout | 10-15 |

## Paleontologic Character

The Nanjemoy formation is marked by a well-characterized fauna, though it is not so abundantly fossiliferous as the Aquia. Among some of the characteristic species are:

*Leda improcera* (Conrad)
*Leda potomacensis* Clark and Martin
*Leda tysoni* Clark and Martin
*Lucina dartoni* Clark
*Lucina whitei* Clark
*Meretrix ovata* var. *ovata* (Rogers)
*Nucula potomacensis* Clark and Martin
*Ostrea sellæformis* Clark
*Venericardia potapacoensis* Clark and Martin[1]

Fossils are found at various points along South and Patuxent rivers, but only in the form of casts.

## Strike, Dip, and Thickness

The strike of the Nanjemoy formation is northeast by southwest, and the dip is about 20 feet to the mile. In this county the formation is not so thick as the Aquia, being about 60 feet as compared with 100 feet for the latter.

## Stratigraphic Relations

The Nanjemoy rests conformably upon the Aquia and is overlain unconformably by the Calvert formation of the Miocene period. Although there is no unconformity between the Aquia and Nanjemoy, it is comparatively

[1] Md. Geol. Survey, Eocene, p. 64.

easy to locate their contact by the occurrence of the Marlboro pink clay at the base of the Nanjemoy formation.

It has already been stated that the Nanjemoy formation disappears, or at least becomes unidentifiable to the east, which brings the Miocene in direct contact with the Aquia.

### Subdivisions

The Nanjemoy formation is divided into two members or substages, the Potapaco and the Woodstock. The former of these received its name from Port Tobacco Creek, Port Tobacco being a corruption of the old name Potapaco used on the early maps of the region. It is separated from the succeeding substage by its fossil content and includes Zones 10-15 of the Maryland Eocene. At the base of Zone 10 is found the characteristic Marlboro pink clay. The Woodstock substage is named from an old estate situated a short distance above Mathias Point on the Virginia side of the Potomac. It comprises Zones 16 and 17 of the Maryland Eocene.

For further details of the Nanjemoy formation, especially the paleontology, the reader is referred to the Eocene volume of the Maryland Geological Survey.

## THE MIOCENE FORMATIONS

### THE CHESAPEAKE GROUP

The term Chesapeake group is used to include that series of Miocene beds which is developed along the Middle Atlantic Slope. The group has been separated into three formations in Maryland, the Calvert, the Choptank, and the St. Mary's. Outside of one isolated exposure of the Choptank, only the basal of these formations occurs in Anne Arundel County.

#### *The Calvert Formation*

The term Calvert formation is derived from the typical development of beds of this age along the Calvert Cliffs in Calvert County. These outcrop almost continuously along the bay shore for a distance of about 30 miles,

and rising in a cliff almost 100 feet high, form perhaps the most striking exposure in the Coastal Plain of Maryland.

### Areal Distribution

With the possible exception of the Aquia and the surficial deposits, the Calvert formation is the most widely exposed of any formation above the Potomac group. It is found at the head of almost every stream from the southernmost extremity of the county northward to a line connecting the Patuxent River with the head of South River. But few exposures isolated from the general area are found and these are small. One of the best occurs in the hill ¼ of a mile north of Iglehart Station; another is found in the hill 1 mile south of Crownsville, just west of the point where the road for Chesterfield branches off. A few other minor exposures occur in the same area. Numerous very good exposures are to be seen in the road cuttings in the more southern area of the county.

### Character of Materials

The Calvert formation is composed essentially of diatomaceous earth, clays, and sands. At the very base is usually found a brownish to blue-green argillaceous sand. The diatomaceous earth—called fuller's earth locally—is of very persistent occurrence near the base of the formation. It is a greenish blue when fresh, but its surface exposure is almost invariably a very light ash gray. The amount of contained sand and clay varies greatly and the material may pass locally into a clay or an argillaceous sand. At other times the earth is quite pure. Just below it is often found a very marly ledge of sand, which may be indurated to form a compact layer of sandstone 6-8 inches thick. Above the diatomaceous earth there usually occurs a yellow to gray extremely fine sand. Nothing similar exists in any formation of the Coastal Plain outside the Miocene, except as reworked in the surficial deposits. It is very loose and the terms "fluffy" and "mealy," often employed as field characterizations, express accurately its appearance and constitution. This is especially true of the upper portion; towards the base it is quite argillaceous and passes by

gradual transition into the diatomaceous earth. A few characteristic sections are given below.

*Section at Fairhaven, ½ mile south of wharf*[1]

| | | Feet |
|---|---|---|
| Pleistocene. | | |
| | Gravel, sand and clay | 10 |
| Miocene. | | |
| Calvert | Diatomaceous sandy clay, bleached to a whitish color, jointed so as to have a rough columnar appearance, carrying *Phacoides contractus* (Zone 3 in part) | 24 |
| | Diatomaceous greenish sandy clay with conchoidal fracture, carrying *Phacoides contractus* and bearing rolled and reworked fossils from the Eocene in lower 2½ feet (Zone 3 in part) | 36 |
| | Total thickness | 70 |

*Section at Fairhaven, ⅛ of a mile north of lower wharf*

| | | Feet |
|---|---|---|
| Pleistocene. | | |
| Talbot | Yellow and gray sandy loam and sand (reworked Miocene) of varying thickness | 6 ± |
| | Somewhat rounded pebbles, quite uniform in size, averaging ¼ to ½ inch, closely packed in matrix of buff sand | 4 |
| | Brownish-black peaty clay | 8 |
| | Knobbly appearing drab-green material, clearly reworked from member below | 1-2 |
| Miocene. | | |
| Calvert | Bluish-green diatomaceous earth compact, covered at high tide, and extending out as a shelf at low tide, due to greater resistance to erosion (see pl. 18B). Exposed | 2½ |
| | Total thickness | 21½ ± |

*Section at Iglehart, ¼ of a mile north of station*

| | | Feet |
|---|---|---|
| Miocene. | | |
| Calvert | Light fluffy sand, gray and buff, buff predominating, grading into member below | 6 ± |
| | Diatomaceous earth, sometimes sandy, sometimes almost a clay, bearing occasional casts of pelecypods and impressions of fish scales, exposed | 10 |
| | Total thickness | 16 ± |

[1] Md. Geol. Survey, Miocene, p. 86.

### Paleontologic Character

The Calvert is at places abundantly fossiliferous, though not so strikingly so in Anne Arundel County as farther south. The forms found in the diatomaceous earth are usually rather small. The most fossiliferous locality observed, and one where the forms were unusually large, was in the cut where the road for Nutwell branches from the main road. The best fossil locality found in the Calvert was near the point where the road crosses the little branch about ½ mile south of Pindell Station. Here the fossils occur as casts in an indurated sandstone ledge about 6 inches thick. Many genera are present, with Pectens especially abundant. These are often very large and are at times stained a rich red brown by limonite and sharply defined against the yellow-gray rock, thus making handsome specimens for collectors. No localities were observed where the shell substance is preserved. For a list of the fossils characteristic of this formation, and for figures and descriptions of those forms likely to be collected, reference should be made to the detailed report found in the Miocene volume of the Maryland Geological Survey.

### Strike, Dip and Thickness

The strike of the Calvert is, like that of the preceding Coastal Plain formations, approximately northeast and southwest. The dip is to the southeast and only about 11 feet to the mile, which is somewhat less than that of the earlier formations.

The exact thickness of the Calvert is not known. Near Davidsonville it is only 50 feet thick, but the upper portion has been removed. A reliable well record at Crisfield, Somerset County, which passes through the entire Miocene series, shows the Calvert to be about 310 feet in thickness. Since all the formations of the Coastal Plain thicken down the dip quite rapidly, it can be said with assurance that the Calvert is much thinner than this in Anne Arundel County. B. L. Miller, however, has mapped it as over 100 feet in the stream bed about 1 mile south of Sudley, and even here the summit is not reached, for a cover of surficial deposits directly overlies it. The Calvert is, therefore, without doubt the thickest formation of the county above those comprising the Potomac group.

### Stratigraphic Relations

In the southern part of the county the Calvert unconformably overlies the Nanjemoy, but farther north it rests apparently upon the Aquia. Near the Maryland-Delaware border it rests directly upon the Rancocas.

The Calvert is overlain unconformably by the Choptank formation when present. In this county the Calvert is almost universally directly covered by one of the Pleistocene terrace formations. It is seldom exposed except in stream valleys.

### Subdivisions

The Calvert formation is subdivided into two members or substages, the Fairhaven diatomaceous earth below and the Plum Point marls above.

The Fairhaven diatomaceous earth receives its name from the village of Fairhaven, near the southern extremity of the county. This member, which is a little over 20 feet thick, comprises Zones 1-3 of the Maryland Miocene.

The Plum Point marls are named from Plum Point in Calvert County, and compose the remainder of the formation. They comprise Zones 4-15 of the Maryland Miocene.

### *The Choptank Formation*

This formation will not be discussed in detail, since its only occurrence in this county is at an insignificant exposure scarcely mapable, visible in the scarp between the Brandywine and Sunderland at Marriott Hill.

The Choptank formation receives its name from its typical development on the north bank of the Choptank River near Dover Bridge. Although named from its occurrence on the Eastern Shore, it is in Calvert County that the best exposures are found. Its exact delimitation has been made difficult by frequent and extended coverings of the Columbia group.

The strike and dip are the same as in the Calvert formation, except that the dip is probably a little less, varying from almost horizontal to 10 feet

per mile. The greatest observed thickness is 50 feet. In the Crisfield well, however, there is apparently a thickness of 175 feet.

Lithologically, the formation is very variable. It includes fine yellow quartz sand, bluish-green sandy clay, slate-colored clay, and at times ledges of indurated rock. Abundant fossil remains are disseminated throughout. Although the Choptank has been shown to rest unconformably upon the Calvert formation, this is seen only through careful study and is not evident in ordinary observations, due to similarity of materials. The Choptank includes Zones 16-20 of the Maryland Miocene.

### *The St. Mary's Formation*

The term St. Mary's formation is derived from St. Mary's County, where it is typically delevoped. The St. Mary's is entirely absent from Anne Arundel County. The best exposures in other areas are found along the bay shore, the Patuxent River, and St. Mary's River, in Calvert and St. Mary's counties.

The strike and dip are the same as in the preceding formation. In the well boring at Crisfield, already referred to, a thickness of 280 feet was found. This decreases up the rise until near Prince Frederick, Calvert County, the formation pinches out. In Maryland the St. Mary's is typically composed of a greenish-blue sandy clay, fossiliferous, resembling greatly the material of the Calvert formation. Locally the beds have been indurated by the deposition of iron; at times, also, clusters of radiating gypsum crystals are found. The St. Mary's lies unconformably on the Choptank formation, and is overlain by the various members of the Columbia group. Its subdivisions form Zones 21-24 of the Maryland Miocene and complete the section as developed in the state.

## THE PLIOCENE (?) FORMATIONS

### *The Brandywine Formation*

The term Brandywine formation is derived from Brandywine, Prince George's County, where the beds of this age are well developed. It was

proposed by Clark[1] in 1915, and has replaced the name "Lafayette," which had been applied to these deposits of the Atlantic Slope.

### Areal Distribution

The Brandywine is, with the exception of the Choptank, the formation most poorly developed in Anne Arundel County. All told, its total extent in the county is only a few acres, and there are only three small areas where it can be said with certainty to occur. The first of these is at Marriott Hill in the southern part of the county, the second at the high hill 2 miles east of Jessups Station, and the third at the high hill ¾ of a mile west of Stony Run Station.

### Character of Materials

It is not to be expected that in so limited an area of preservation a very general idea of the character of the materials could be obtained. Hence it is necessary to describe the characteristic development in areas outside of Anne Arundel. The best summary of this for the areas immediately adjoining this county is to be found in the Pliocene and Pleistocene Volume of the Maryland Geological Survey.

The materials composing the Brandywine formation consist of clay, loam, sand, gravel, and iron ore, which is present in the deposit as a cement, binding the loose material together in ledges of local development. These materials were imperfectly sorted by the waves of the Brandywine sea, so that they are now found intermingled in varying proportions. Although there is a rough bipartite division in the deposits as a whole, whereby the gravel occurs in greater abundance at the base, and the sand and loam at the top of the formation, yet these elements are mixed together in a confusing manner. Irregular beds or lenses of loam, sand, or gravel, are locally developed throughout the formation. Usually the Brandywine is capped by a deposit of loam varying from a few inches to 10 feet or more, and with an average thickness of about 5 feet. Along the Piedmont border this loam contains considerable iron and has a decided orange color, but in southern Maryland changes to a buff or yellow.

[1] Amer. Jour. Sci. (iv), vol. xl, 1915, p. 499.

FIG. 1.—VIEW SHOWING RECENT FILLING OF PATUXENT RIVER ABOVE LYONS CREEK.

FIG. 2.—VIEW SHOWING MODERN SEA CLIFF AND A PLEISTOCENE CYPRESS SWAMP IN THE TALBOT FORMATION, 1¼ MILES SOUTH OF BODKIN POINT.

Not a single clean-cut section is exposed in Anne Arundel County. In the hill west of Stony Run Station the surface of the hill is very gravelly, with a few boulders. The gravel are well rounded to subangular and quite coarse; they are as a rule quartzose, though occasional boulders of igneous rock are observed. The matrix appears to be a sand, colored brown by a large amount of iron-stained argillaceous material. In the exposure east of Jessups the upper member is well developed as a fine, brown, hard packing loam. At Marriott Hill the loamy phase is entirely lacking. The sand is coarse, loose, and almost white, resembling greatly a recent beach sand. The slope is gravel-covered, and the gravels for the most part only slightly rounded. They are as a rule rather small, although some larger ones up to 5 inches in greatest diameter were observed. Large fragments of ironstone conglomerate are numerous, and these and the gravel have doubtless acted together to protect the summit of the hill from degradation. The great freedom of the body of the mass from the coloring matter, so pronounced in most Brandywine strata, is the chief feature at this exposure.

## Physiographic Expression

As has already been brought out at some length, the Brandywine represents the oldest and highest of a series of old sea floors successively developed along the Atlantic Coast. Their maximum westward extension was reached in Brandywine time, when the waves of the Atlantic beat directly against the cliffs of the Piedmont Plateau. As the sea retreated the sea floor rose as a terrace parallel to its original position. Therefore, as pointed out by Shattuck, true dip plays very little part in this formation, the dominant element being the original slope as determined by the sea bottom upon which the deposits were laid down. At present the Brandywine occurs at an elevation of 200-300 feet in various parts of the county, while in the most westerly exposures of the state it attains an altitude of about 500 feet. Little trace of the original terrace structure remains in Anne Arundel County, but at the three points described above there is little difficulty in identifying the deposits as Brandywine when they are considered both lithologically and physiographically.

### Paleontologic Character

No fossils are known from the Brandywine of this region, and although in other areas plant and animal remains have been referred to the Brandywine, they have not been sufficiently definite to determine its age, the nearest key to which is found at present in its stratigraphic relations.

### Thickness

The Brandywine, as a whole, probably does not average over 50 feet in thickness. At Marriott Hill this thickness is probably attained. At the two other localities cited it is somewhat less—30-40 feet.

### Stratigraphic Relations

The very nature of the Brandywine—that of a surficial deposit formed by a sea gradually encroaching inland beyond the limits of previous inundations—leads to the natural supposition that it would be found resting unconformably on formations of various age, and this is indeed the case. In Anne Arundel County it is found resting upon the Miocene and Raritan only, although in the railroad cut just south of Naval Academy Junction it may possibly rest upon the Magothy. These relations throw a little light upon the age of the Brandywine, for, since it holds a position between the Miocene and the Sunderland, the formation may be considered as probably Pliocene in age. This conclusion, however, is not accepted by all, and the age of the Brandywine is still a matter of earnest discussion.

## THE PLEISTOCENE FORMATIONS

### THE COLUMBIA GROUP

The term Columbia formation was introduced by MeGee[1] in 1886 from its typical development in the District of Columbia. Shattuck later raised this to a group term and recognized four divisions. These divisions are not characterized by forming paleontologic or lithologic units—they

[1] Report of the Health Officer of the District of Columbia for 1884-85, 1886, p. 20.

are too similar to be thus differentiated—but as pointed out by Shattuck, they do form pronounced topographic units in that each division consists of a well-defined terrace lying at a definite level and usually separated from the succeeding terrace by a scarp representing an ancient sea cliff. Viewed from this standpoint alone, the Brandywine would form one of these topographic units, but as already stated, certain other stratigraphic relations give evidence that this formation is considerably older. It is to be borne in mind, however, that some careful students feel that the Brandywine forms an integral part of the Pleistocene period.

### *The Sunderland Formation*

The term Sunderland formation is derived from the village of Sunderland, Calvert County, near which it is typically developed. The name was first applied by G. B. Shattuck[1] in 1901.

#### Areal Distribution

South of parallel 39°, which runs just north of Annapolis, the Sunderland caps almost every divide. From here towards the north of the county it has been almost entirely removed, although a few patches have been left along the Big and Little Patuxent in the western part of the county. There is, in the extreme north, another extensive terrace of Sunderland age extending from South Baltimore westward almost to Stony Run, forming a comparatively level plain 6 miles long and averaging a little less than 1 mile in width.

#### Character of Materials

The Sunderland formation, like the Brandywine, is composed of loam, clays, sands, gravels, and occasional boulders, with no observable regularity of arrangement, except that the finer material tends to be at the top and the coarser at the bottom. In the exposure stretching westward from South Baltimore this is very uniformly the case, there being found at the base cross-bedded, ferruginous gravels with occasional larger boulders

[1] Shattuck, G. B., Johns Hopkins Univ. Circ., No. 152, May, 1901.

overlain by a fine brown loam some 10 feet in thickness. In the southern development homogeneous sands predominate, especially towards the Patuxent, and for miles scarcely any gravel can be found.

The origin of the larger boulders here and in the other terrace formations is attributed to the transporting power of blocks of ice which in Pleistocene time floated down the expanded streams and gradually dropped their load in this warmer climate. It is not to be expected that these boulders would be confined to any one horizon, and as a matter of fact they are not. Large fragments of rock often occur in the loam, with the complete absence of other coarse material which proves their origin by some transporting power other than water. These boulders are largely of igneous origin, although some large quartzite fragments occur. In the road cutting ¾ of a mile due east of Shipley, these boulders are unusually well developed at the contact with Patapsco white clay. Many of them are 1 to 2 feet in diameter. Although the gabbro blocks average much the larger, one quartzite boulder was observed 4½ feet in greatest diameter. The gravel phase of the Sunderland may be seen to great advantage in the various pits overlooking South Baltimore just opposite the car works.

### Physiographic Expression

The Sunderland forms the plain lying at the level immediately below that of the Brandywine, from which it is separated by a scarp. This scarp, owing to the poor development of the Brandywine within the county, is rarely seen. It is found, however, fairly well developed at the three exposures of Brandywine already referred to, namely, Marriott Hill, 1 mile west of Stony Run Station, and 2 miles east of Jessups Station. Throughout the Coastal Plain the Sunderland is also separated from the Wicomico below by a well-developed scarp.

Because of its height above tide and its greater age relative to the lower lying terraces, the Sunderland has been as a rule changed from a flat surface to a rather rolling plain, at times much dissected. Where stream erosion has been most active the deposits may be entirely removed. Occasionally when none of its deposits remain *in situ* its former presence

is evidenced by the topography and by boulders too heavy to be removed by those streams which bore away the lighter loam, sand, and gravel.

### Paleontologic Character

No fossils are known from the Sunderland of Anne Arundel County. Identifiable plant remains have been found at Point of Rocks, and near the headwaters of Island Creek, both in Calvert County. Among the forms found are representatives of *Quercus* and *Ulmus,* practically indistinguishable from certain oaks and elms which inhabit this region at the present time.

### Thickness

The maximum known thickness of the Sunderland is about 80 feet. It will probably average somewhat over 30 feet for Anne Arundel County.

### Stratigraphic Relations

Just as with the Brandywine, so with the Sunderland, overlap may bring the formation in contact with any of the underlying formations. In this county the Sunderland is found resting upon every older formation except the Choptank, which is present in only one very limited exposure. The Wicomico forms a fringe about the outer border of the terrace and penetrates it as a re-entrant in the valleys of the larger streams.

## *The Wicomico Formation*

The term Wicomico formation is derived from Wicomico River in Southern Maryland. It was proposed by G. B. Shattuck[1] in 1901 and represents the upper part of what had previously been designated Later Columbia.

### Areal Distribution

The Wicomico formation of the county is best developed along the Patuxent River, where it occurs in closely adjoining patches separated only by the erosion valleys of small tributary streams. The chief excep-

[1] Shattuck, G. B., Johns Hopkins Univ. Circ., No. 152.

tion is found in the area bordering the upper valley of the Little Patuxent where it is not found. Small patches of Wicomico are also found along Magothy and Severn rivers.

### Character of Materials.

The material composing the Wicomico formation is similar to that of the Sunderland. It consists of gravel, sand, clay, peat, and often large ice-borne boulders, all grading into each other horizontally and vertically. The sands are often cross-bedded. These are usually covered by a brown loam, quite free from gravel, but containing occasional large boulders which are usually of igneous rock, especially gabbro. The character of the sands and clays depends largely on the region where they are examined, since they are composed of material derived with comparatively little change from the formations below. Thus in a Miocene area the sand is often fine; in an Eocene or Upper Cretaceous area it may contain considerable glauconite, while in a Potomac area sands when present are coarse and often contain an admixture of reddish clay. The gravel is obtained largely from the Potomac formation or from the Sunderland above.

### Physiographic Expression

The Wicomico formation is developed as a terrace fringing the Sunderland above. The valleys of Wicomico time form re-entrants into the Sunderland terrace and often are of great width as compared with their length—an evidence of their estuarine character. As already pointed out, the scarp separating the Wicomico from the Sunderland is one of the most pronounced features of the Coastal Plain. Excellent examples of this, although of limited extent, are to be found at Woodwardville, and especially $\frac{3}{4}$ of a mile west of Omar. At both these localities the Sunderland is largely lacking, but the scarp rising abruptly at the limit of the former Wicomico sea is very striking.

The Wicomico has been subjected to considerable erosion at some localities and there presents a gently rolling surface. At other points, as

at Woodwardville, it is almost as flat to-day as on its first appearance above the level of the sea.

### Paleontologic Character

No organic remains have been observed in the Wicomico of Anne Arundel County. The only locality from which Wicomico fossils have been obtained is Queen Anne (Hardesty), Prince George's County, where, in a deposit of carbonaceous material about 20 feet thick, impressions of grasses and stems together with some insect remains have been discovered.

### Thickness

The maximum known thickness of the Wicomico is 70 feet at Turkey Point in Cecil County. The formation probably does not average over 20 feet for Anne Arundel County and is often much thinner.

### Stratigraphic Relations

The Wicomico formation may rest upon any of the older formations of the county.

## *The Talbot Formation*

The term Talbot formation is derived from Talbot County, on the Eastern Shore, where this terrace is especially well developed. The name was suggested by G. B. Shattuck[1] in 1901 to include the lower part of McGee's Later Columbia.

### Areal Distribution

The Talbot formation is developed along the Patuxent River in closely adjoining patches as far north as Hill's Bridge. Like the Wicomico it is often found along the larger estuaries. Unlike the Wicomico, the Talbot is well developed along the bay shore. Two areas are of special note, since they are by far the largest and best preserved areas within the county. The first is that district composing what is known as "The Swamp," lying between South River and Rockhole Creek. The second area, typically developed though considerably smaller, is found towards the eastern extremity of the neck northeast of Annapolis.

[1] Shattuck, G. B., Johns Hopkins Univ. Circ., No. 152.

### Character of Materials

The materials composing the Talbot differ but little from those of the other Pleistocene formations. Peat, loam, clay, sand, gravel, and ice-borne boulders are all found, often in one section. The relative proportion of these constituents depends very largely upon the lithologic composition of the formations from which they were derived. The Talbot seems to have differed somewhat from the earlier Pleistocene formations, at least in Anne Arundel County, in a greater predominance of swamp conditions. At almost every extensive exposure of Talbot within this county evidences of such conditions are found in beds of peat and the remains of huge cypress trees, either in the form of branches and "knees," or of great stumps now partially submerged but usually well above the water at low tide. Such sections are found a little over a mile below Bodkin Point; on the east shore of Gibson Island ½ mile north of Mountain Point; at Greenbury Point east of Annapolis; and at Saunders Point near the mouth of South River. The wide distribution of this type of deposit makes clear the extensive presence of swamp areas in Talbot time, especially when it is borne in mind that very similar conditions are shown in many sections in Talbot County just across the bay. Sections indicative of such conditions in the older Pleistocene formations are present in other areas, but seemingly are much less common than in the Talbot. This is certainly true for Anne Arundel County.

The bipartite division noted in other Pleistocene formations is also found in the Talbot. At times the upper loamy phase is predominant, as in the area known as "The Swamp."

Only a small portion of "The Swamp" is really swampy, and such portion is confined entirely to its margin or to the heads of the small coves which project into the land. It is so low and flat, however, that in the spring during heavy rains or during seasons of unusually high tides a considerable portion is at times covered with water. The materials are almost entirely a very fine loam. When wet it has a light drab tone, but when dry is of an ashy color, almost white. Because of the almost entire absence of sand it forms a very hard compact mass when dry. It is a

curious fact that scarcely a gravel is seen on the surface over the entire flat, and in the cliffs not a single one was found in the loam. The whole region is very thickly settled, more so than any other part of southern Anne Arundel County. Most of the people live by oystering.

Good sections are far more common in the Talbot than in the other Pleistocene formations. A few of these will be given:

*Section between Parker's Island and the mouth of Herring Creek, "The Swamp"*

| | | Feet | Inches |
|---|---|---|---|
| Pleistocene. | | | |
| Talbot..... | Fine loam, light drab below, ashy white above.. | 6 | |
| | Coarse greenish-blue sand with some few gravel | 1 | 6 |
| | Yellow clay greatly iron-stained..... | | 4 |
| Miocene. | | | |
| Calvert..... | Diatomaceous earth, exposed..... | 1 | |
| | Total thickness ..... | 8 | 10 |

*Section at Bay Ridge, ⅜ of a mile southwest of Tolly Point*

| | | Feet | Inches |
|---|---|---|---|
| Pleistocene. | | | |
| Talbot..... | Buff to yellowish-brown sandy clay loam grading downwards into next member..... | 3 | |
| | Greenish-gray to light brown sand, containing considerable glauconite ..... | 9 | |
| | Pebble band in matrix of sand similar to sand above. Pebbles small, few exceeding 1 inch in diameter ..... | 8 | 6 |
| | Gray sand containing considerable glauconite, pebbles of clay, and quartz pebbles..... | | 14 |
| | Tough yellow clay representing the weathered portion of the clay below..... | | 6 |
| | Black clay with stems of plants and trees, some layers consisting of quite pure peat with beetle wings, and a few small quartz pebbles.. | 3-6 | |
| | Bright green sand containing much glauconite with pockets of gravel and some bands of iron stone ..... | 3-4 | |
| | (In one place two boulders over 1 foot in diameter occur in this layer. Glauconitic sands belonging to the Eocene rise above water at the center of the bluff.) | | |
| | Total thickness .....28-32 | | 2 |

*Section at Greenbury Point, Severn River*

| | | Feet | Inches |
|---|---|---|---|
| Pleistocene. | | | |
| Talbot | Yellowish-brown clay loam containing a few small pebbles | 5 | |
| | Bright olive-green sandy clay, very hard | 1 | 6 |
| | Brown to gray sand argillaceous in places, containing single pebbles and pebble bands | 6 | 6 |
| | Pebble ironstone conglomerate | | 3-6 |
| | Plant bed, a black compact clay with some moulding clay containing plant stems and huge cypress stumps exposed at high tide. (Some of the stumps showing in the water about 20 feet from the shore are fully 8 feet in diameter.) | 4 | 6 |
| | Total thickness | 17 | 9-12 |

## Physiographic Expression

The Talbot formation comprises the lowest of the terraces developed along the Middle Atlantic Slope. Since it is the lowest and also the youngest, the factors working towards the destruction of its original character have been reduced to a minimum, and as a result the flat featureless topography of a land recently raised above the sea is here preserved in a striking manner. It furnishes a connecting link so clear as to leave no possibility of misinterpretation between the recent deposits and the older, more dissected terraces.

The Talbot formation forms a fringe around the edge of the Wicomico above, and occasionally around the Sunderland when the Wicomico is lacking. It penetrates the upper terrace in the form of re-entrants which clearly mark the lines of a former well-marked drainage, although at present these valleys often play a very subordinate part in the topography.

## Paleontologic Character

The Talbot formation is the most fossiliferous of the Pleistocene formations. In Anne Arundel County it has yielded plant remains and at Bodkin Point the casts of *Unios*. Three fossil localities are known in the county, the first at Bodkin Point, the second at Bay Ridge, and the third

at Fairhaven. The most fossiliferous locality anywhere known in the Talbot is found at Wailes Bluff, Cornfield Harbor, St. Mary's County. The following list of forms from Anne Arundel County is collected from the descriptions in the Pliocene and Pleistocene Volume of the Maryland Geological Survey:

*Osmunda* sp.? (Swamp Fern), Tolly Point (Bay Ridge)
*Fagus americana* Sweet (American Beech), Bodkin Point
*Nyssa biflora* Walter (Water Tupelo or Gum), Bodkin Point
*Pinus echinata* Miller (Yellow Pine), Bodkin Point
*Pinus strobus* Linné (White Pine), Bodkin Point
*Robinia pseudacacia* Linné (Locust), Bodkin Point
*Taxodium distichum* (L) L. C. Richard (Bald Cypress), Bodkin Point
*Vitis* sp. (Grape), Bodkin Point
*Xolisma ligustrina* (Linné) Britton (Privet Andromeda), Bodkin Point

### Thickness

The maximum thickness of the Talbot formation is very little over 40 feet. In Anne Arundel County it does not average over 20 feet, and very often thins down to a mere veneer covering the underlying deposits.

### Stratigraphic Relations

The Talbot supposedly lies unconformably on the outer edge of the Wicomico terrace, although the great similarity of materials has made it impossible to identify absolutely any such relation. The Talbot is usually separated from the Wicomico and also from the Recent deposits by a scarp. It is to be noted that the Talbot and Recent at times grade into each other by gentle slopes with no sign of a sea cliff. In fact the sea is often building up land in the form of bars instead of cutting a cliff.

## *The Recent Deposits*

The Recent includes all those deposits laid down from the end of Talbot time to the present. It is the period in which we now live and furnishes the criteria on which are based the theories of conditions in past geological time. Although some terrestrial deposits must be included here, aqueous deposits are in this area of far greater importance.

Mention has continually been made in the preceding paragraphs of the removal of this or that formation from certain areas, or of its more or less complete dissection. This means that the deposits have been transported to some other locality, and since the composition of the materials composing these deposits is largely insoluble in surface waters, there has been little physical change during transportation. To discover what is being done with the removed material is not difficult—even a casual observer may see that it is being carried away by the streams which bear it as far as their currents are swift enough to hold it in suspension. When their currents are checked, the material is deposited. Evidence of this is found at the mouth of every stream in the county. It is perhaps most commonly evidenced by the smaller creeks which empty into such estuaries as the Severn. The inhabitants of the county all bear witness to the deeper conditions which formerly prevailed along these minor creeks. As a concrete example, take the inlet just east of Little Round Bay. The topographic map shows a swamp developed at its head. This is a wide reed-covered slimy morass, almost impassable. Even the inlet below the swamp is very shallow and is being rapidly encroached upon. Yet a reliable man, a native of the region, states that 25 years ago lumber was loaded directly on boats which penetrated inland $\frac{1}{4}$ of a mile above the present head of the swamp. This is not an exception, but the general condition. To see that this is not limited to the minor creeks it is only necessary to note the pronounced filling which is accumulating in the Patapsco. Fifty years ago this stream was navigable with much more freedom than at present—to realize this it is only necessary to call to mind the former accessibility of Elkridge Landing.

In addition to the filling of the smaller streams, the larger rivers are continually bearing material into the bay and depositing it along the shores, especially near their mouths. While this material is distributed over a large area and does not accumulate so rapidly as in smaller streams nearer the source of supply, it is, nevertheless, a process always active, and the constant dredging necessary along the bay in order to keep the channels open to navigation bears witness to its effectiveness.

The active erosion of the waves along certain portions of the bay shore is also an important factor in building up the Recent deposits.

The material thus gained by stream and wave action is more or less sorted and spread over the floor of the rivers and bay. The depressions left by the late Talbot sinking are being filled in and a level terrace-like basement is being built up. The materials furnished by the rivers consist mostly of various kinds of sand and clay which, during their long transport, become intermingled and lose much of their original individuality. Much of the wave-derived material, on the other hand, is deposited comparatively near the source of supply and the lithologic character of the Recent deposits in this case depends largely on the formation composing the sea cliff. Where this contains much gravel, the Recent deposits will also contain much gravel; where it is glauconitic, they will be glauconitic; where argillaceous, they will be of mud; where formed in an imponded stream, deposits of peat may be expected. This is just what has gone on in past geologic periods, and while this is not the place for details it is evident that a careful study of the phenomena of the Recent stage is essential to an understanding and interpretation of the geological records of the past.

## INTERPRETATION OF THE GEOLOGICAL RECORD

The following attempt to picture the physical conditions under which deposition took place in the various formations of the Coastal Plain and to decipher the meaning of the geological record revealed in these beds, is based on whatever facts have come to hand and is by no means restricted to observations from such a limited area as Anne Arundel County. Although opinions may differ as to the exact interpretation of certain features to be discussed, the general trend of events as outlined below is such as is accepted by most geologists who have worked in the Coastal Plain.

### SEDIMENTARY RECORD OF THE POTOMAC GROUP

West of the Coastal Plain lies that great mass of ancient and highly metamorphosed rocks which compose the Piedmont Plateau. These have been above the sea since very early geologic time and have passed through

many vicissitudes of folding and erosion. Among the erosional phenomena has been a series of four reductions to approximate base level; the earliest and most extensive of these is known as the Schooley Peneplain, and was probably formed in Jurassic time; next was formed the Weverton peneplain, of either late Jurassic or early Cretaceous age;[1] following these came the Harrisburg and Sommerville of Early and Late Tertiary time. These are interesting at this point from the fact that the Schooley and Weverton peneplains—possibly the Weverton alone—prepared the way for the deposition of the sediments of the Potomac group, for after the old Archean rocks had been reduced to base level in the Jurassic, an uplift with tilting towards the east took place which allowed a transgression of the sea and at the same time caused a rejuvenation of the rivers, renewed active erosion, and produced rapid deposition. Thus was inaugurated the sedimentation of Potomac time.

As has been brought out in the description of the formations composing this group, it is characterized by extreme lithologic variability. Coarse gravel, sand, and clay exist in close horizontal proximity. Cross-bedding is common. Numerous plant remains are found, varying from comminuted leaf fragments through leaves and twigs to great lignitized and ferruginized trunks. Occasionally the remains of great land animals are found. All of these conditions are such as are duplicated to-day in continental deposits, in delta deposits at the mouths of great rivers, in estuarine deposits, and partly at least in near shore marine deposits. The great extent of the Potomac beds is against their origin purely as delta deposits. Although the estuarine origin of the deposits is usually assumed, it is possible that this has been over-emphasized.

The beds first to be deposited were made up largely of materials drawn directly from the long exposed and much weathered surface of the crystalline rocks. Prominent among these constituents were quartz, clay, and arkose. Arkosic sand is especially characteristic of the basal Potomac formation, the Patuxent. Gravels and clays were also brought down by the rivers, but the sands predominate.

[1] Md. Geol. Survey, vol. vi, pp. 76-77.

After erosion had proceeded for some time the land surface was again lowered, though not to its former level, so that the lower courses of the streams running across the Patuxent surface became areas of swamp land. In these were laid down that series of clays and iron ores which is called the Arundel formation. It is evident that such a formation must be composed of a series of lenses rather than of one continuous sheet of deposits, as is the more usual conception of a formation. After a considerable body of these clays had been laid down the land again rose and both the Patuxent and Arundel were subjected to erosion as is proven by the unconformity with the Patapsco formation above. Then once more a sinking began, and continued until the Arundel and large parts of the Patuxent had been again submerged.

The Patapsco formation, thus inaugurated, is a formation dominantly argillaceous, although beds of very homogeneous clean sand may occur. The physical conditions of deposition were evidently quite similar to those of the Patuxent. For the first time the remains of undoubted dicotyledonous plants are found, but the flora as a whole is closely related to that of the older Potomac formations. The Patapsco sediments were the last to be laid down in Potomac time. When the land rose and Patapsco deposition was ended, equilibrium apparently reigned throughout this section of the continent during a long period, for by the next submergence dicotyledons had so developed as to be the dominant forms and were of an Upper Cretaceous type.

### SEDIMENTARY RECORD OF THE UPPER CRETACEOUS FORMATIONS

As has already been emphasized, the Upper Cretaceous opened with conditions similar to those which had held sway in the preceding Potomac epoch. The sands, gravels, and clays of the Raritan differ little from those of the Patapsco. The clays of the Raritan are as a rule less highly colored than those of the Potomac group. Certain parts of this formation, as the glass sands and pottery clays along the Severn River, are exceedingly free from iron. The great contrast between the Raritan and the Potomac group is furnished by the abundance of dicotyledonous plants in the former.

After a time the deposits of Raritan time were lifted above sea level and subjected to erosion. Streams began to wear away the easily-eroded materials and considerable valleys were cut. This is well attested by the pronouncedly undulating unconformity which separates the Raritan from the overlying Magothy formation. When the land again sank and deposition began once more, what is now designated Magothy time was introduced. At the opening of this age conditions similar to those of the Potomac epoch prevailed. Very variable deposits of sand and clay and some gravel were laid down. Many decayed stems and trunks were buried and now appear as lignite, while the gums secreted by them are found scattered through the deposits in the form of amber. In the quieter waters leaves sank to the bottom and were covered by clay. Occasional pockets of glauconite are found. If estuarine conditions prevailed, incursions of the sea must have taken place for glauconite is wholly of marine deposition. Farther north, in New Jersey, strictly marine invertebrate remains are found. In Maryland the near-shore and estuarine character of the Magothy seems to have persisted to the close of the age. Viewed broadly, the Magothy was evidently a time of transition towards the undoubted marine phase which was to characterize the remainder of the Coastal Plain formations.

The Magothy was terminated by an uplift which brought the recently deposited sediments at least partially above water. The amount of erosion to which these were subjected seems to have been variable. At some points there is little to mark the line of contact between the Magothy and Matawan and deposition was probably continuous. In other cases, as along the Chesapeake and Delaware Canal and the western shore of Little Round Bay the contact is extremely undulatory; the Magothy may rise several feet above tide, appearing and disappearing several times in a short distance.

When the land once more sank, truly marine conditions, such as are usually associated with the Upper Cretaceous, were ushered in. The sea of this time was more extensive than that of the Magothy, for the Matawan is sometimes found resting directly on the Raritan at points where there

FIG. 1.—VIEW SHOWING GRAVEL PITS IN THE WICOMICO FORMATION AT BRAGERS, W. B. & A. R. R.

FIG. 2.—VIEW OF A PIT OF THE WASHINGTON HYDRAULIC PRESSED BRICK COMPANY, 1 MILE SOUTH OF HARMANS.

is no reason for supposing the removal of pre-existing Magothy deposits. The deposits of the Matawan are rather uniform mixtures of sand, clay, glauconite, and mica, although the mica is somewhat variable in amount.

The region most favorable to the formation of greensand is near the boundary between the Shallow-water and Deep-water zones, *i. e.*, at a depth of about 100 fathoms. The maximum depth is about 900 fathoms. From this certain deductions may be drawn as to the conditions of deposition of the Matawan, namely, that it was laid down under fairly uniform conditions, but too near the shore to furnish ideal conditions for the formation of glauconite. Such a conclusion is borne out by the large amount of lignite sometimes found in the Matawan. It is interesting to note that in the Matawan at Millersville, Anne Arundel County, a specimen of *Dammara borealis* Heer has been found, which is closely related to a Magothy form and shows here also the close relationship of these formations. In addition to this, the writer found in 1909, in the concretions of the Woodbury clay at Lorillard, New Jersey, a leaf of *Ficus* sp., also closely related to a Magothy form. This bears further evidence to the close union between the Magothy and Matawan formations throughout the entire area of deposition and adds probability to the idea that the unconformities found are only of local importance. The sequence of events, therefore, would be, first the estuarine and near-shore deposits of the Magothy, then a slight uplift bringing local areas above tide, followed by a renewed advance of the sea and the deposition in many localities of the Matawan formation as a series of beds continuous with those of the Magothy below. This sinking continued without a conspicuous break into Monmouth time. Deeper conditions prevailed however, for the Monmouth transgresses the Matawan. Conditions were evidently more favorable for the unhampered production of glauconite which, with sand, composes the formation. This type of deposits must have had its contemporaneous near-shore equivalent, but this has been entirely removed, or else is undifferentiable from the formation below.

This completed the history of Upper Cretaceous sedimentation, so far as Anne Arundel County is concerned. To the north, and especially in

New Jersey, two additional formations, the Rancocas and Manasquan, were laid down, both continuing the general physical conditions just described. Conditions were even more favorable for the formation of glauconite and none of the Maryland beds can approach these in the purity of this deposit. It is possible that these highest Cretaceous formations were laid down in Anne Arundel County; if so, they were removed during the period of erosion preceding the deposition of the Eocene. There is an equal possibility that uplift ended the period of Cretaceous deposition sooner in this area than in the region to the north, and that sediments corresponding to the Rancocas and Manasquan were never laid down in this county.

### SEDIMENTARY RECORD OF THE EOCENE FORMATIONS

When the land again sank after the Upper Cretaceous uplift, there was an immediate return to conditions very similar to those which had prevailed during the latter part of Upper Cretaceous sedimentation. Glauconite was formed in large quantities and was intermingled with deposits composed largely of sand. Large numbers of Mollusca and Gastropoda swarmed in this Eocene sea. These conditions continued until about the middle of Eocene time, when there was a pronounced change which caused the sedimentation to take on the most argillaceous character developed since the Magothy. This was at the ushering in of Nanjemoy deposition with its locally developed unfossiliferous and non-glauconitic clay. It is difficult to explain this bed of homogeneous pink clay. It may be explained as due to a shallowing of the sea which brought a fringe of deposits above shore as a low-lying plain across which the rivers meandered to the sea and deposited beds of clay. This hypothesis is borne out by the fact that the thickest beds of clay are found towards the landward margin with, so far as can be determined, decrease in thickness down the dip. Whatever be the explanation of the clay, the conditions governing its formation were of short duration, and there was soon a return towards the conditions of early Eocene time with the formation of glauconite. The return to the former state was not complete, however, for the glauconitic sands contain a much larger per cent of clay than did those of the Aquia.

Molluscan life, though abundant, does not seem to have been so profuse as in the earlier history of the period. These conditions, as represented along the Middle Atlantic Slope, persisted with little change to the end of Eocene time.[1] The uplift which terminated the period in Maryland brought to a close those conditions which had persisted rather closely since the beginning of the Matawan.

### SEDIMENTARY RECORD OF THE MIOCENE FORMATIONS

The Miocene was a time of deposition of clays, diatomaceous earth, and fine sands. These conditions can be accounted for by supposing that the subsidence at the beginning of this epoch produced a coast of low relief off which sluggish streams, usually too slow-moving to bear coarse sand, not to mention gravel, gradually deposited their loads. The presence of diatomaceous earth, formerly thought to indicate deep waters, is satisfactorily accounted for if freedom from sedimentation is assumed in some quiet basin. This condition was best fulfilled at the beginning of Miocene time. Throughout most of the epoch, conditions seem to have been extremely favorable for molluscan life, as is testified by the great abundance of their fossil remains.

When Miocene sedimentation was completed, and the uplift which terminated it had taken place, a final end was put to this and the preceding types of deposits; before the deposition of the next sediments conditions which made possible those deposits known as "surficial" were introduced and have continued to the present.

### SEDIMENTARY RECORD OF THE BRANDYWINE FORMATION

The sedimentation of Brandywine time was ushered in by conditions different from any of those preceding. They resembled most closely those prevailing at the opening of Patuxent time, for during the Miocene uplift erosion had proceeded so far that the land was nearly base-leveled. Then, just as in Patuxent time, at the very opening of Coastal Plain history,

[1] Younger Eocene sediments have an extensive development in the South Atlantic and Gulf states.

this peneplain was tilted towards the sea and the streams rejuvenated. These brought down deposits of gravel which were spread along the shore. At the same time the waves were at work pushing back the shore line. The rivers emptied the heavier part of their load here so that as the shore line retreated it was followed by an almost continuous sheet of gravel. This operation may have been assisted by a slight progressive sinking of the land. While the gravel and boulder layer was gradually making its way farther and farther west, on its outer margin the finer load of the streams was being deposited as evidenced by the capping of loam which is found to-day so extensively and uniformly developed over the coarser materials.

The general trend of this time, viewed both from the destructive work of the waves in cutting back a cliff and from the constructive work of the deposits near shore, was to form a comparatively level series of deposits. As soon as the beds were raised above sea level, erosion set in and dissected them to a considerable degree. Then the sea again advanced and the Pliocene period as developed in this region was ushered in.

### SEDIMENTARY RECORD OF THE PLEISTOCENE FORMATIONS

So much has been said concerning Pleistocene history in the discussion of the topographic history of the county that little need be repeated. It has been pointed out that by careful study a series of terraces can be discovered, each terminated by a scarp which runs across the country for miles more or less continuously, and each successively lower than the one preceding and at very nearly a constant level. Each of these elevated terraces and cliffs is ascribed to an advance of the sea, the westernmost limit of the sea being in each case the point at which the old sea-cliff (scarp) is found. It is evident that the highest terrace must be the oldest, for it is the greatest in extent, and if younger than the others would have submerged them and destroyed all traces of their former existence. The same argument may be advanced for each terrace in reference to those lying below it. The record of Pleistocene events was, then:

*First,* the deposition of gravels, sands, clays, and ice-borne boulders along the margin of the sea and in the greatly enlarged estuaries, accompanied by the cutting of a cliff along the margin of the sea. *Second,* the elevation of these deposits approximately parallel to themselves, and the subjection of these deposits to erosion. *Third,* another but lesser advance of the sea, with the beginning of deposition of another series of deposits.

Since three terraces are known this cycle must have been completed three times. The first cycle resulted in the formation of the Sunderland terrace, the second of the Wicomico, and the last of the Talbot. Conditions were very similar during all this time, but as pointed out earlier, the Talbot seems to have been an age during which the land lay nearer water-level than in the others, as evidenced by the greater number of typical swamp deposits found.

From the above account it is evident that considerable is known concerning the remote past of Anne Arundel County. Conditions have been far different from what they are at present. The whole of the county has often been under water and when, as in the time represented by the unconformities there has been land, its extent and configuration have been quite different from what obtains at present. Indeed, only until very recent geologic time, in the latter half of the Pleistocene, did the county take on anything like its present form. Under these circumstances much room is left for the play of fancy, and many interesting pictures of past conditions can be created. The writer has attempted to keep close to certainty in most of the interpretations given; to the reader is left the pleasure of filling in the gaps as may seem to him most concordant with the facts presented.

# THE MINERAL RESOURCES OF ANNE ARUNDEL COUNTY

BY

HOMER P. LITTLE

## Introductory

The mineral resources of Anne Arundel County include none of the so-called precious metals nor any gem stones. They are confined almost entirely to structural materials as gravel, sand, clay, and a limited amount of stone; and to marls, diatomaceous earth, and iron ore. Although these materials, especially the structural ones, are not of great value in limited amounts, yet the almost inexhaustible supply of some of them coupled with the proximity to Baltimore, enhances their value greatly. Although the "sands of Anne Arundel" are often spoken of somewhat contemptuously, the fact remains that many a good fortune lies waiting those who will develop them, as is being gradually discovered. And this holds for other of the natural resources of the county.

## The Natural Deposits

### THE CLAYS

The following paragraphs on the clays of Anne Arundel County are largely based on the report by H. Ries, on "The Clays of Maryland," Volume IV of the Maryland Geological Survey.

#### *The Potomac Clays*

All of the Potomac formations contain clay of commercial value but in greatly varying amounts.

The clays of the Patuxent formation within this county are of little importance; in fact only one locality is known where development is at

all likely, namely, on the H. Brown estate at Timberneck on Deep Run. There the clay is probably 10 feet thick and of considerable horizontal extent. According to Ries it is of a refractory nature, fusing slightly above cone 27.

The clays of the Arundel formation are of much more commercial value. These clays, mostly blue and somewhat siliceous, are of good plasticity and are used for the manufacture of common and pressed brick, terra cotta, roofing tile, and common pottery. The common presence of nodules of iron carbonate may make it necessary to put the clay through rolls in order to exclude them. The chief occurrence of Arundel clays in the county is, as will be seen by reference to the geologic map, along the northwest boundary. Here are enormous masses of clay. The chief objection to them is that the iron ores are usually very abundant; however, clays of better grade, free from iron ore, are at times found. Little advantage is being taken of these deposits, although the clay of an abandoned iron mine 1½ miles east of Laurel has been dug for the manufacture of brick. A very plastic red-burning potter's clay occurs on the property of Charles Needer, 1 mile northeast of Patapsco Station.

The Patapsco clays are more extensively worked in Anne Arundel County than those of any other age. The development in proportion to the supply is, however, very meager. The typical variegated "terra cotta clay" especially, which occurs in unlimited amounts suitable for the manufacture of brick, is almost untouched. This was at one time dug near Glenburnie and manufactured into tiling, but for some reason the venture was not a success, though apparently through no fault with the supply. The higher grade Patapsco clays are less common in the county. However, a good quality blue clay was dug for years on the estate of Frank Hancock, 1½ miles south of Hawkins Point, and shipped to the Bennett Pottery Company of Baltimore until forced out of the market by competitors who could supply at a lower rate.

A type of Patapsco clay adapted to the manufacture of smoking pipes is mined at a point about ½ mile south of Wellhams on the Annapolis Short Line. An important deposit of gray-black gritty clay, located

about ½ mile south of Harman on the Pennsylvania Railroad, has been worked for some years by the Washington Hydraulic-Pressed Brick Company. The deposit is favorably located and considerable operations are going on. Deposits of a white clay are found 1 mile and 2½ miles south of Glenburnie. The former has been used in the manufacture of buff brick. The latter, occurring on the H. T. Wade estate is quite refractory, for it is not vitrified at cone 27.

### *The Upper Cretaceous Clays*

The only clay-bearing formations of this group are the Raritan and the Magothy. The Raritan clays are well developed in Anne Arundel County, especially along the Severn River. Operations, however, have declined. Various localities where workable Raritan clays are found are given in Volume IV, Maryland Geological Survey, pp. 407-413. It is to be noted that many of these are regarded as Patapsco in the present report. True Raritan clays of considerable extent are found below Bodkin Point on the bay shore, where they are easily accessible. A white clay occurring at Earleigh Heights, suitable for the manufacture of white bricks and refractory ware, is worthy of notice. This clay is barely vitrified when heated to cone 27.

Certain clays of the Magothy formation are suitable for the manufacture of pressed brick and terra cotta, and might also be of value in the manufacture of paving brick if mixed with some other clay of the region. Deposits of this sort are found on the Magothy River at Swan Cove. The clay deposits of this formation, as it is developed in Anne Arundel County, are confined largely to Magothy and Severn rivers.

### *The Eocene and Miocene Clays*

The only Eocene clay of any commercial value is the Marlboro clay at the base of the Nanjemoy formation. Only one deposit of any importance—and that not utilized—occurs in Anne Arundel County. This is found at the point where the road from Davidsonville to Annapolis crosses the upper course of Beards Creek. The Marlboro clay is a fine-

grained red material, fairly plastic, suitable for pressed brick and possibly for the manufacture of paving brick.

The Miocene contains no important deposits of clay. The diatomaceous earth of this period, though resembling a clay in appearance, is not really such, and will be discussed under a separate heading.

### *The Brandywine and Pleistocene Clays*

The Brandywine formation contains in some counties clays suitable for the manufacture of brick. In Anne Arundel, however, the formation is so sparingly developed that it is of no value whatever.

The clays of the Pleistocene are never used for anything except common brick. These clays have not been utilized in Anne Arundel County except to a very limited degree, and it is probable that those of the Sunderland and Wicomico formations never will be because of the amount of sand present. The Talbot, however, contains deposits which offer distinct possibilities in the area south of Bodkin Point. Ries has tested these carefully and finds them of good plasticity. They burn to a good red color, and the only objection seems to be a rather high shrinkage. The fact that this material, which is large in extent and so easily accessible to Baltimore City, would probably lend itself to the manufacture of paving brick, should give it an added importance. A greenish-drab clay at Greenbury Point, Severn River, is said to be used at the Naval Academy for moulding purposes and to be especially desirable because so very hard when dried.

## THE SANDS

There are three principal classes into which the sands of Anne Arundel fall: First, building sands; second, glass sands; third, moulding sands.

The moulding sands have not been developed, but several prospects have been opened. These lie near the head of Saltworks Creek, Severn River, and are in the gray-green glauconitic sands of the Monmouth formation. According to information obtained from local inhabitants, some of this sand was shipped to Baltimore for moulding purposes and a deal

for the purchase of the beds nearly consummated. For some reason, however, this did not materialize.

The chief occurrences of glass sand in the country are found along the banks of Severn River. Similar but less extensive deposits are found on Magothy River. All of these deposits occur in the Raritan formation. The only active operations at present are at the pits of the Brennan Sand Company, just west of Forked Creek. In 1908 a strip about 10 feet in thickness was being removed. Borings showed the glass sand to extend downwards about 30 feet more. Of the remaining 47 feet penetrated, much was a good building sand, although one clay lens 10 feet thick was encountered. Formerly this sand was removed by tunneling, but at present the overburden is removed and an open-pit method employed.

Building sands are developed in Anne Arundel County in enormous quantities, and their value is becoming more and more appreciated. They are confined largely to the Potomac group, to the two lower formations of the Upper Cretaceous, and to the Talbot. They are all very similar in character.

Considerable openings have been made in the Patuxent formation 1 mile east of Laurel, from which it is said the material for the grading of the grounds about the new Union Station at Washington was taken. This material inclines to be gravelly, especially in an opening ½ mile north-northwest of the one just mentioned. Much of it, however, is of the usual texture of building sand.

The Patapsco sands are very accessible to Baltimore. The chief operations in this formation are those of the Rayner pits at South Baltimore. An opening has been made ½ mile south of Stony Run Station, much of the product being shipped to Arlington.

The most extensive supply of sand in the county is probably that of the Raritan. Large pits are found in this formation towards the head of both Severn and Magothy rivers, especially on the latter, where whole headlands have been removed. A large pit, well equipped with gravity haul, is that of W. F. Clarke, 1 mile south of Severn Station on the Pennsylvania Railroad. The walls have in places a vertical height of 25 feet and the lower limit of the sand has not been reached.

Sands have been dug from the Magothy formation by Captain Jeff Cook along Cornfield Harbor, near the mouth of Magothy River, and are said to be of good quality.

The Talbot sands are chiefly exploited at present along the eastern shore of Marley Creek. One of the largest pits in the county, that of Wm. R. Della, is located along this creek ¾ of a mile north of Marley. This pit has been in operation for six years and has furnished a large amount of high-grade sand. A smaller pit is located 1¼ miles north of here. Similar deposits, though of much less vertical thickness, were formerly worked near the mouth of Furnace Creek along the south bank, but are now abandoned. The sand-digging industry, however, is at present one of the most flourishing of those which involve the mineral resources of Anne Arundel County.

It should not be overlooked in this discussion that these sands, forbidding and desolate as they may appear to one unfamiliar with their possibilities, are wonderful trucking grounds and raise many types of produce with great success. A rapid influx of industrious Germans is bringing about the development of hitherto unused lands, and the sandy fields of Anne Arundel are constantly adding increased wealth to the county.

### THE GRAVELS

Outside of the Pleistocene formations no gravel deposits of any importance are found in Anne Arundel County. The largest supplies are found along the Patuxent River. The most accessible of these deposits are those developed in the Wicomico formation by the Washington, Baltimore and Annapolis Railroad at the points where it crosses the Big and Little Patuxent rivers. A good quality of gravel, but only 2 to 3 feet thick, is being removed from the surface of the Wicomico plain ¼ of a mile west of Woodwardville. The supplies most available for Baltimore are found in the Sunderland formation at South Baltimore and are being worked in connection with the Rayner sand pits. In contrast to the deposits previously mentioned these contain a large amount of ferruginous matter, and the material is often cemented to a conglomerate. Small openings have been made in similar materials along the road about 1 mile

east of Patapsco Station. In fact, that large area of Sunderland extending from South Baltimore westward through Linthicum and Shipley to near Patapsco Station is almost everywhere underlain by a good quality of ferruginous gravel 8 to 10 feet thick, well adapted for use as road metal.

### THE BUILDING STONES

The supply of building stone in Anne Arundel County is extremely limited, as would be expected in a Coastal Plain region. There are, however, two stones which are somewhat used—the Raritan and Patapsco brown indurated ferruginous sandstone and the Raritan white quartzose sandstone. The former is the more common and is quite widely used in some regions for underpinning. Although iron cemented it seems to be quite durable. One house just north of Cattail Creek, Magothy River, whose every line shows it to be one of the oldest of the region, is built entirely of this stone—or possibly of Magothy sandstone—and is in most excellent condition. A church located 1½ miles east of Jessups Station is constructed of similar material.

The white quartzose sandstone has been little used in the construction of buildings even where occurring in large masses, due probably to its great hardness and the consequent difficulty of working. In Prince George's County, about 1 mile west of Priests Bridge, a chapel has been built of this material. A deposit in Anne Arundel County, ¾ of a mile north of Lemons Bridge, was used in the construction of railroad culverts over the Patuxent. The largest deposit in the county occurs ½ mile east of Elvaton. Little use is made of this, although quarrying to a small extent has been carried on in the past.

The brown ferruginous sandstone occurring in the Magothy and Eocene formations is occasionally used as underpinning and in minor construction, but is of little importance.

### THE MARLS

Marl in general is divided into two classes, shell marl and glauconitic marl. The former depends on the presence of calcium carbonate for its beneficial action, the latter essentially on the presence of potash. The

fact that in these latter, calcium carbonate from contained shells and phosphates from mineral phosphates are also usually present, gives them an additional value.

Shell marls are practically lacking in Anne Arundel County. The glauconitic marls, on the other hand, are exceedingly abundant throughout all that large area in which the Monmouth and Eocene formations are present. The black marls of the Matawan, though not so rich in glauconite, also fall into this class. When one considers the tremendous amount of this material available, the ease with which it is dug, and the great benefits derived through its use, as witnessed by many competent observers, it seems remarkable that no more advantage is taken of this great natural resource. Especially is this true when it is borne in mind that Anne Arundel is a county whose lands have long been under cultivation and throughout which many farms are falling into decline, while others have been totally abandoned because of exhaustion of the land.

### THE DIATOMACEOUS EARTH

Diatomaceous earth is a substance clay-like in appearance, but in reality composed largely of the siliceous skeletons of microscopic plants known as diatoms. It is used as an absorbent in the manufacture of dynamite and as a base for polishing compounds; its nonconductivity of heat makes it useful as a packing for steam boilers, pipes, and especially for safes.

Large deposits of diatomaceous earth are developed at the base of the Calvert formation, and these appear in force in the southern part of Anne Arundel County. Owing, however, to the limited demand for the material at present, only one company is at work. This is located at the mouth of Lyons Creek on the Patuxent River and has its principal workings just over the line in Calvert County. Similar deposits which may prove of importance, if the demand for the earth increases, are found along Herring Bay at the extreme northern end of the Calvert Cliffs.

### THE IRON ORES

The iron ores of Anne Arundel County, though little utilized at present due to greater and more easily worked supplies elsewhere, have been in

the past a source of considerable wealth, and in the event of a future exhaustion of deposits now worked will certainly once more take an important place among the natural resources of the county.

The iron deposits really belong to two quite different types, which may be called the iron ores proper and the paint ores. The former occur largely in the Arundel formation. Two varieties are common—the carbonate, or "white ores," and the hydrous oxide, or "brown ores." The northwest edge of the county is dotted with abandoned iron mines. One mile south of Portland Station is an old furnace which certifies to the past activity of the region in that its slag has been used for road metal. The clays of the Arundel have by no means been exhausted; in fact, their supply has apparently been scarcely touched. As evidence of the abundance of iron in these clays there was called to the writer's attention a well recently dug about 1 mile east of Patapsco from which over 500 pounds of ore was removed. This found a ready market at Muirkirk.

The paint ores are clays exceedingly rich in hematite, and occur quite commonly near the base of the Patapsco formation. The only active operations in the county at present are being carried on by William Dagler near the old Reynold's mine, $\frac{3}{4}$ of a mile south-southeast of Hanover. A deposit of paint ore about 1 foot in thickness outcrops in the road $\frac{3}{4}$ of a mile south of Patapsco Station. What is perhaps the same ledge outcrops $\frac{1}{4}$ of a mile south of Patapsco, but contains a much greater proportion of clay.

### THE PETROLEUM AND NATURAL GAS

Various rumors occur from time to time of the finding of natural gas within the county. A boring was made about 2 miles west of Annapolis on such a rumor, but without results. In a well dug near the brickyard on the north bank of Curtis Creek near the road, it was reported that a strong odor of gas was noticed and that on lighting a match ignition took place and the gas burned with a feeble flame. This was at a shallow depth —only about 15 feet—and probably was marsh gas that had its source in a Talbot peat bog. It is quite certain that gas or petroleum in amounts economically valuable will never be found in Anne Arundel County.

### THE LIGNITE AND PYRITE

Although not of commercial importance at present, the deposits of lignite and pyrite occurring at North Ferry Point, Magothy River, were once of much significance. Ducatel, in the Transactions of the Maryland Academy of Science, Volume I, 1837, wrote:

"The deposits of lignite and pyrites, already referred to as occurring at Cape Sable [North Ferry Point] on the Magothy, furnishes the material from which large quantities of alum and copperas are annually manufactured for the supply of nearly the whole Union."

These workings have all been abandoned for years, and due to the abundant supplies now at hand for the production of both alum and copperas, it is scarcely probable that these deposits of Anne Arundel County will again become valuable.

## THE WATER RESOURCES OF ANNE ARUNDEL COUNTY

### SPRINGS

Springs are very abundant throughout much of Anne Arundel County. Many of the springs utilized as such are scarcely worthy of the term, however, consisting merely of seepages of water into holes dug through a thin covering of sand to a clay bottom. Yet such springs are frequently utilized in spite of the danger of surface contamination. They serve to bring out the fact that the numerous alternations of sand and clay in the county furnish conditions very favorable to the formation of springs.

The two horizons at which springs are most often found in this county are at the contact of the Potomac and Pleisetocene formations and just below the contact of the Matawan and Monmouth formations. The water of the former is usually cool, clear, and tasteless; that of the latter, though often containing iron, is seldom disagreeable in springs, though in deep wells it may be entirely useless. The springs from this latter horizon are extremely abundant, and in the area of the Matawan-Monmouth contact many of the inhabitants depend wholly upon them for their supply.

Springs are of course found at other horizons, especially intraformationally in the Potomac group, where there are rapid alternations of sands and clays, but the two most constant occurrences are those cited above.

SHALLOW WELLS

In the southern half of Anne Arundel County the whole region is covered to a large extent by the surficial deposits, especially those of the Sunderland, although towards the Patuxent valley the Wicomico and Talbot are well developed. The supply of most of this region is procured near the base of these surficial deposits where their gravel beds rest upon the less permeable beds below. The depth of the wells, then, varies as the thickness of the Pleistocene covering, ranging rather constantly from about 15 to 35 feet. On some of the high narrow divides it is necessary to go as deep at 100 feet for a supply of water. Although the supply of these wells is closely dependent on the downward percolation of meteoric waters and is thus governed by the rainfall, yet because of the usual absence of extended droughts the supply of water is quite dependable.

North of this area the surface deposits disappear and the depth to which wells must be dug depends on the distance to be penetrated before some porous stratum, suitable for carrying water, can be reached. At Chesterfield the wells run 60 to 80 feet deep. Those living at a lower level depend for their supply largely on the springs which issue from near the top of the Matawan. About Millersville, especially along the road to the west, the inhabitants use driven wells largely, averaging 120 to 135 feet deep, pumping the water by means of gasoline engines. To the west of the station a very fine water is obtained in dug wells at a depth of about 70 feet. The source of this water seems to be the Raritan, perhaps near the contact with the Patapsco.

Across the Severn in the region of Arnold, dug wells run 25 to 100 feet. These shallow towards the bay, where some are only 12 feet deep. Throughout the whole county to the north and east, the wells keep within these same limits, the depth varying with the elevation. Pumphreys, with wells varying from 10 to 105 feet, offers as wide a variation as any. Linthicum is about the same. Frequently water is found at two levels even in comparatively shallow wells. For instance, on the high levels around Brooklyn, water is often found at 30 to 35 feet, but this supply is uncertain and most of the inhabitants find it necessary to sink their wells to 50 or 60 feet where a dependable supply is found.

Conditions are very similar in the western part of the county. Along the ridge to the west of Harman's the wells run about 40 feet deep. If, however, a well is begun on an Arundel surface this must be pierced before water can be obtained, since the Arundel is essentially a clay formation throughout and has no water-bearing horizon. An instance of this was noted 1 mile east of Patapsco Station, where, at a house located near the summit of the Arundel formation, a well had at the time of the writer's visit been dug through over 90 feet of solid clay without reaching water. The lower down in the Arundel surface a well is begun the less the depth which must be penetrated, for the Patuxent formation directly below is an important water carrier.

### ARTESIAN WELLS

#### *Waters of the Potomac Group*

The waters carried by the Potomac formations are doubtless the most important of the county, and are the most widely utilized. These have been most thoroughly prospected by the Brooklyn and Curtis Bay Light and Water Company, which has a series of wells ranging from 109 to 400 feet. One well passed through water-bearing horizons at 180 and 200 feet, but found its principal source at 337½ feet. Another well nearby is 575 feet deep. At 300 feet it struck a little dirty water; at 375 feet bed-rock is thought to have been encountered; continuing in this to 575 feet no water was found. This makes it improbable that the crystalline rocks are good water-carriers in this area. The horizon at the base of the Potomac is uncertain, but several horizons are found in the group which bear water. The experience of the water company shows that conditions are favorable to finding a supply between 100 and 200 feet, although failures occur. A series of wells at East Brooklyn from 100 to 375 feet all found good supplies of water at points ranging betwen these depths. A well at Seawall, 562 feet deep, procured no water; yet one at Fort Armistead, Hawkins Point, 572 feet deep, pumps 3000 gallons per minute. Both of these wells must have reached the horizon at the base of the Potomac group and give further indication of the pockety nature of the water. At Eastport, wells at 208 and 218 feet gave a good supply with a flow of 50 gallons per minute

from the shallower one. A well at Bay Ridge, east of Annapolis, yielded water from the middle Potomac at 470 feet. This water was sulphurous and irony, but the record is valuable in that it shows the presence beneath a large area in the northeast section of the county of a fairly constant supply of water from the Potomac beds at moderate depths. About midway between these areas is a well at Round Bay which yielded a strong flow of somewhat irony though not disagreeable water at 225 feet. It is to be borne in mind that all these wells are located close to sea level, and that at higher elevations borings would have to be deeper and flows could not be expected. The records show the source of these waters to be usually a sand and gravel bed. Often the occurrence of a clay cover is noted.

*Waters of the Upper Cretaceous*

The Magothy is the chief water-carrier of the Upper Cretaceous. Flowing wells at Annapolis are said to have reached this horizon at about 200 feet.[1] The writer visited a well on Luce Creek, Severn River, just as boring operations were being completed. A good flow was obtained at 135 feet from material which was undoubtedly Magothy. Calculating from the dip per mile, this is doubtless the same horizon which was water-bearing at Annapolis. The general relations of the Magothy should make it a good water carrier wherever its sandy phase is penetrated. Water should therefore be obtained along the line of strike at depths corresponding to the above plus additional altitude. The depth to which borings must go increases 25 to 30 feet per mile to the southeast. Water from this same horizon or from the Raritan was obtained in a 150-foot well at Revell. This water has a "marshy" taste, and so much iron was present as to make it useless. On standing, this oxidized and appeared as a red sediment. An impregnation with iron and sulphur is quite frequent in the Magothy, although the water may be very satisfactory at other times. The supply from this horizon, however, is more apt to be distasteful than that from the Potomac.

[1] Darton, N. H., U. S. Geol. Survey, Bull. 138, p. 127.

### *Waters of the Eocene*

The waters of the Eocene are extensively utilized in the southern part of the county where these beds are covered by the younger formations and are not dissected by streams. Such an area is found in the general region of "The Swamp." There are over 30 flowing wells in this region ranging from 110 to 150 feet in depth. The flow is as a rule 8 to 10 gallons a minute, but is occasionally less, and is said to be decreasing slightly. The water-bearing horizon seems to be about midway in the Aquia. A well was sunk at Lothian to a depth of 300 feet, but no water was found except near the surface. This well, however, did not penetrate deep enough to test all the horizons from which "The Swamp" obtains its water. For instance, several wells at Galesville are 150 feet deep. To find this level the well at Lothian should have gone 320 feet as nearly as can be calculated. And to strike the horizon at Leitchs Wharf an even greater depth would have been required. These horizons, however, vary according to the amount of argillaceous matter locally developed in the Aquia, and it is impossible to tell, except at closely adjacent points, at just what depths water will be encountered.

### *Waters of the Miocene*

The Miocene farther south yields copious supplies of artesian water. In Anne Arundel County it is usually too near the surface and too dissected to be productive, and so far as known no wells obtain water from this horizon. At North Chesapeake Beach, just over the line in Calvert County, a good flow of water was obtained from the Miocene at a depth of 85 feet.

# THE SOILS OF ANNE ARUNDEL COUNTY

BY

J. C. BRITTON AND C. R. ZAPPONE, JR.

## INTRODUCTORY

The relationship existing between the geology and the soils of any given area constitutes an important phase of the agricultural investigation of the region. The influence exerted by the geology on the soils is of great importance in the theoretical consideration of the origin of the soils and of practical importance in determining the area, the characteristics, and the resources of each particular soil type. All of the geological formations of the world have been divided and sub-divided into formations and groups of formations in accordance with their sequence of deposition, as indicated by their relative positions with regard to one another and in accordance with the stage of development of fossil life forms that have been buried in the different layers.

Since the basis of geological classification is one of age and of place relationships, while the fundamental principle of soil classification depends upon differences of soil texture, a given geological formation may give rise to two or more soil types. On the other hand, since the mineral composition and rock texture of different geological formations may closely resemble each other though their ages differ, so a single soil formation may be derived from two or more geological formations. Physiographic relations to stream drainage and to climate are also considered in the classification of the soils.

Anne Arundel County lies wholly within the Coastal Plain region of the state, all the soils of the county being derived from the unconsolidated sediments belonging to the Mesozoic and Cenozoic portions of the geological column.

In general there is a fairly definite relationship between soils and topography, the lighter types occurring most abundantly on the slopes and the heavier ones being more generally confined to the level uplands. There are, however, some large areas of gently rolling to nearly level sandy soils. In the broad, flat, plateau-like areas there has been little surface wash. The effect of erosion as related to the removal of the finer constituents has been minimized, and therefore changes in the original material have been mostly changes in the structural and chemical characteristics rather than in texture.

Much of the former level sea floor, or old stream terraces, has been badly dissected by erosion, particularly through the development of the drainage system. Deep valleys have been cut through the uplifted deposits, and in the vicinity of these the surface configuration has been so altered that it is difficult to conceive the existence of a former level or nearly level plain.

In the classification of the soils those types that are similar in their most prominent characteristics as color, structure, mineralogical composition, drainage condition, productiveness, and topography have been grouped into series. Differentiation in the series is determined by the relative content of gravel, sands, silt, and clay. Exclusive of the recently formed bottom land, there are in Anne Arundel County five distinct series of soil, including eighteen types.

The most abundant and widely distributed group of soils has been included in the Sassafras series, the members of which occur upon the low foreland terraces as well as upon the plateau-like uplands. The surface configuration and usual coarse texture of the substratum have favored good surface and underdrainage, a condition which has had much to do with the development of the characteristic uniformly reddish-yellow to reddish-brown color and the friable structure of the subsoil portion of the several types. The individual particles seem to have suffered less attrition than in case of the members of several other series, particularly the Norfolk, as is evidenced in the usual higher content of minerals other than quartz. These soils of the Sassafras series are the most productive soils of the region.

In those imperfectly drained areas that have been subjected to intermittent wet and dry stages the same material that gave rise to the silt loam member of the Sassafras series has undergone an unfavorable structural change and has assumed an ashy gray to nearly white appearance. This soil is very poorly aerated, is dense instead of friable, as in case of the Sassafras silt loam, and is very much inclined to run together and compact following rains and freezes. This type has been given the name Elkton silt loam. It is confined largely to the flat forelands of the southern portion of the county. Its productiveness is much below that of the Sassafras silt loam.

In the northern part of the county there is an extensive area of light-gray to pale-yellow loose sand which averages at least 3 feet in depth. Unlike the Sassafras sand, this soil—the Norfolk sand—has a relatively very low content of minerals other than quartz. The appearance indicates that the deposits giving rise to this type have been subjected to much more severe attrition through the action of waves and tides than had those that give rise to the corresponding member of the Sassafras series, causing more complete destruction and removal of the less resistant minerals. The type is less productive than the Sassafras sand; it is less loamy and somewhat more droughty.

Crossing the county about its center there is an extensive belt of soils derived from greensand which traverses the state in a southwesterly direction from the Delaware line near Warwick, Md. Geologically this belt is known as the Aquia formation of Eocene age. The formation is characterized by its high content of the mineral glauconite (greensand), which is a complex silicate containing potassium and phosphoric acid. The reddish-brown soils having greenish-yellow or olive-colored subsoils derived from this formation have been included in the Collington series. These soils rank high in agricultural value.

From the variegated, sticky, plastic clay formation, which outcrops in many places in the northern part of the county, are derived the soils of the Susquehanna series. These are characterized by the mottled scarlet, white, and drab color and extremely plastic structure of the subsoil. The soil portion of the sand member of the series was laid down as a mantle over

the clay under very different conditions than those existing at the time the latter was deposited. The Susquehanna soils as developed in this area are of very low agricultural value, especially where the plastic clay comes near the surface.

A considerable total area of recently formed alluvial soil has been mapped under the name of Meadow. The undifferentiated materials of this classification have been deposited from running water, having been derived from the various soils occurring in the drainage basins. Deposition is still in progress, additional material being laid down at each overflow.

Tidal marsh includes reworked materials that have been deposited in protected situations along the coast line of Chesapeake Bay. These flat deposits are subject to daily inundation by tide.

## THE SOIL TYPES

The areas of the several soil types occurring in Anne Arundel County are given in the following table:

*Areas of Different Soils*

| Soil | Acres | Per cent |
|---|---|---|
| Sassafras fine sandy loam | 42,880 | 15.5 |
| Collington sandy loam | 41,600 | 15.1 |
| Sassafras sand | 40,320 | 14.6 |
| Sassafras silt loam | 31,040 | 11.2 |
| Norfolk sand | 25,024 | 9.1 |
| Meadow | 19,648 | 7.1 |
| Susquehanna sandy loam | 16,064 | 5.9 |
| Sassafras fine sand | 15,936 | 5.8 |
| Sassafras gravelly loam | 11,968 | 4.3 |
| Elkton silt loam | 10,176 | 3.7 |
| Susquehanna gravelly loam | 6,720 | 2.4 |
| Sassafras sandy loam | 4,032 | 1.5 |
| Sassafras loamy sand | 4,032 | 1.5 |
| Sassafras loam | 1,728 | .6 |
| Susquehanna sand | 1,600 | .6 |
| Collington sand | 1,216 | .4 |
| Susquehanna clay loam | 896 | .3 |
| Tidal marsh | 640 | .3 |
| Collington gravelly sandy loam | 320 | .1 |
| Total | 275,840 | ..... |

### THE COLLINGTON SANDY LOAM

The Collington sandy loam is found in a very well defined area extending from near West River along the shore to beyond the Severn, and west as far as the Patuxent River. Near the outer margins of this area it is found only in the ravines and along the streams. It is therefore evidently a lowland type.

To a depth varying from 6 to 20 inches the soil consists of a brown to reddish-brown medium to coarse sand often containing considerable proportions of particles of a dark-green color, which are partially disintegrated fragments of glauconite from which the type is derived. The subsoil to a depth of 36 inches is a greenish-yellow or olive-colored sandy loam to sandy clay, also containing considerable green glauconitic sand. From 6 to 15 feet below the surface numerous iron concretions occur in all sorts of fantastic shapes. A few feet below this there is usually a compact bed of greensand marl. The thickness of these beds varies from a few inches to several feet. Below this may be found a thick layer of sand or gravel resting upon another bed of green marl. This order is continuous in some places to great depths.

The surface of this type varies from almost flat to gently rolling and does not rise to an elevation greater than 170 feet. The original forest growth has largely been removed, except on some of the rougher portions. Pine is usually the predominating growth in mixed forests, and there are extensive pine forests on some of the more sandy portions of this type.

The Collington sandy loam is considered one of the best soils in the area for general farming and truck growing. It may be used for the production of almost any crop. In places where the sand of the top soil is of considerable depth, excellent truck crops are produced. Where the clay comes nearer the surface, general farming crops are more commonly grown and good yields are secured. This soil seems to be especially well adapted to the growing of alfalfa, and some very fine fields of this crop may be seen in the vicinity of Annapolis. Wheat, corn, oats, rye, tobacco, Irish potatoes, and nursery stock are grown with success. The soil seems to be especially well adapted to fruit growing. Small fruits, particularly

strawberries, produce abundant and profitable yields on the more level sandy parts of the type.

Where the topography is rough and broken, this type is subject to severe erosion, and in such places more or less of the top soil has been removed, leaving only a thin layer of soil or exposing the raw subsoil. Such places are extremely unproductive and in most cases are left uncultivated. A cover crop should be kept on the sloping areas as much of the time as possible, in order to prevent washing.

The use of commercial fertilizers in connection with this soil should be given special mention. Chemical analysis shows that glauconite, from which this soil is derived, is composed of potash, lime, magnesium, iron, and some phosphoric acid. The content of potash is high, and the analysis also shows that these soils are relatively high in this constituent. For this reason fertilizers with a low percentage of potash can be profitably substituted for the grades often used. The great need of the Collington sandy loam is organic matter, and by using leguminous plants to supply this deficiency the nitrogen requirement may also be wholly or partially supplied.

The marl underlying this soil, being in some places comparatively rich in potash, phosphoric acid, and lime, has some value as a fertilizer and is used to a limited extent on the soils of the county. It seems to be especially beneficial when applied to heavy silty or clay soils. The use of deposits, which analyses show to be valuable, should be more extensive.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

*Mechanical Analyses of Collington Sandy Loam*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21452..... | Soil..... | 1.7 | 15.8 | 22.7 | 42.4 | 2.9 | 7.5 | 6.6 |
| 21453..... | Subsoil..... | 1.7 | 15.4 | 15.8 | 29.2 | 5.9 | 9.7 | 21.9 |

### THE COLLINGTON SAND

The Collington sand is found in small areas south of Annapolis around Spa and Back creeks and in the vicinity of Arundel-on-the-Bay. A few small areas were also found southwest of Annapolis, on each side of South River.

The surface soil, to a depth varying from 10 to 20 inches, is a yellowish- or reddish-gray medium sand resembling Sassafras sand in texture and containing usually a small amount of greensand, which gives it the Collington characteristic. The subsoil to a depth of 36 inches consists of a greenish-yellow loamy sand, quite sticky at 36 inches. Sometimes at 36 inches a rather stiff olive colored sandy loam to sandy clay identical with the subsoil of the Collington sandy loam is encountered.

The natural forest growth on this type is usually pine. The surface is for the most part quite flat, but the drainage is good on account of the loose, open nature of the soil proper and the depth to underlying clay, which is found uniformly at 36 to 40 inches. Crops on this type do not suffer to such an extent from drought as do those of the deeper sands of other series.

The Collington sand is an excellent truck soil and especially well suited for melons and cantaloupes. Small fruits also thrive and are of exceptionally fine flavor.

This soil is deficient in vegetable matter, but as it is underlain with clay it will admit of permanent improvement, and the plowing under of green crops with liberal applications of lime would be profitable.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

*Mechanical Analyses of Collington Sand*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21448..... | Soil..... | 0.2 | 18.2 | 24.3 | 45.5 | 4.0 | 2.8 | 4.5 |
| 21449..... | Subsoil ..... | .3 | 15.0 | 23.3 | 41.5 | 3.7 | 2.5 | 13.5 |

### THE SASSAFRAS SILT LOAM

The soil of the Sassafras silt loam is a light yellowish-brown to buff silt loam, becoming darker immediately below the surface, usually changing to a dark-yellow or brown color. The subsoil to a depth of several feet is a compact yellow to reddish-yellow silty clay. Beds of fine gravel or fine mealy gray sand are sometimes found at a depth of 5 to 12 feet below the surface. In places where the drainage is deficient the soil is less friable and the color much lighter. Scattered throughout the whole soil mass are minute flakes of mica, which show very plainly on a broken surface of a piece of the soil.

The topography of the Sassafras silt loam is level or very nearly so. The silt content of the soil portion varies somewhat with the character of the surface. Where the land is slightly rolling the silt content is lower, and where the topography is quite flat the content is much higher.

The soil works well when moist, but is troublesome to get into proper condition if allowed to become dry after plowing, especially where the organic-matter content is low. The soil should usually be harrowed immediately after it is plowed. If two teams are not available, then only as much surface should be broken as can be harrowed the same day. Such land should never be plowed when wet, as in such cases it sometimes takes several years to restore good structural condition. Good farmers are always careful about this. It will always pay to wait until the moisture content of the soil is just right before starting the plow, even though the crop may be planted a little late.

This type of soil is well distributed throughout the area, occupying the low flat terraces along the bay and estuary streams, the flat tops of hills, and the flat to undulating stream divides. If the topography is level or nearly so and the drainage good, the soil will be typical no matter what the elevation may be. There is a range in elevation from about 10 or 15 feet above tide level to something like 200 feet. The greatest development of the higher lying phase is found in the southern part of the county, where it occurs as broad uniform flat to undulating interstream divides. On the foreland section of the peninsula lying between the

Severn and the Magothy rivers is quite a large area of the low-lying phase of the type, which will be described more in detail further on.

In agricultural value the two phases are not widely different. The most noticeable differences are the better drainage of the higher lying phase and the usually higher moisture content of the lower. The type suffers perhaps less from drought than any other soil in the county, and if kept well cultivated in dry seasons, so as to maintain a good surface mulch, there need be little fear of crop injury as a result of lack of moisture.

The Sassafras silt loam is productive if carefully handled and responds readily to methods of soil improvement. Being quite heavy the subsoil will retain for a long time any additions in the way of stable manure or green crops plowed under. The soil is almost always deficient in organic matter, so that the incorporation of such material is especially profitable. Some of the farmers on this type say that the beneficial effects of a liberal application of barnyard manure are noticeable for many years. When such applications are occasionally given, or green crops plowed under with a liberal addition of lime, the soil, if worked properly and at the right time, is a loose tillable loam of splendid structure and especially when deeply plowed of high water-holding capacity.

The matter of deep plowing is of much importance on this type. The subsoil is of such a heavy resistant nature that plant roots cannot penetrate deeper than the plow has gone. If it is plowed shallow, the crops grown will be shallow rooted, and therefore not nearly as resistant to drought as they should be. When any crop has only a shallow feeding ground a good yield cannot be expected. In one case on this type unusually deep plowing resulted in a marked improvement in the corn crop and the yield of the wheat crop which followed was nearly double what it had been in other years. Subsoiling would doubtless be beneficial if carefully done.

Some farmers believe that the continued use of commercial fertilizers causes the soil to compact. Many farmers working this soil are convinced that methods of general soil improvement, particularly including the

incorporation of vegetable manures, should be practised rather than the constant use of commercial fertilizers.

The type is well adapted to the general farm crops. Wheat, corn, oats, rye, hay, and Irish potatoes are the crops which give the best returns. In localities near a cannery the growing of tomatoes is sometimes practised and some fair yields are reported; but some of the lighter soils are better adapted to this crop. Tobacco is also occasionally grown on the Sassafras silt loam with fair returns as far as yield is concerned, but the quality is often not what the market demands.

The yield of the various crops grown in this soil is, on the average, fair, but with careful manipulation the yield of all crops should be increased. Twenty-five to 30 bushels of wheat per acre are often grown, but the average is somewhat below this. The average yield of corn is about 45 to 50 bushels per acre, with an occasional yield of 75 bushels.

Clover and timothy are the usual hay crops. It is sometimes difficult to secure a satisfactory stand of clover, very likely because the soil is often in need of lime. At least 30 bushels of lime per acre should be applied and thoroughly mixed with the soil before sowing the clover seed. It is needless to state that a perfect seed bed should be prepared for clover.

Irish potatoes are quite largely grown on this soil, but the seed bed is not deeply prepared and the tubers tend toward ill shape and sogginess. For potatoes the soil should be plowed deep and subsoiled if possible. Large quantities of barnyard manure should be applied to the preceding crop. If applied to the potato crop scabby tubers will usually result.

The oat plant requires just such a soil as the Sassafras silt loam, and oats should be more generally grown than at present. The land for this crop should be plowed instead of disked, as is the practice with some farmers, and it is considered best to plow the land in the fall.

### *Sassafras Silt Loam (Poorly Drained Phase)*

The poorly drained phase of the Sassafras silt loam is found only on the low forelands and is closely associated with the Elkton silt loam. To a depth of 5 to 10 inches the soil consists of a brownish-gray compact silt loam containing some fine sand. The subsoil is a light-brown or yellowish-

brown heavy, compact silt loam to 36 inches, mottled with yellow or gray at the latter depth. The content of fine sand increases and in some places a pale-gray almost pure sand is found 4 to 6 feet below the surface.

The topography is very gently rolling to almost flat, and the natural drainage is sluggish. The mottled color of the subsoil is the result of this poor drainage and the lack of aeration. Where artificially drained by open ditches the soil becomes quite productive and some good crops of corn and tomatoes are grown, to which crops the type seems especially well adapted. Tomatoes grown on this soil, like those grown on the Elkton silt loam, are finer than those grown on the lighter soils and are highly prized for canning.

While this type is highly productive, if properly tilled, it is not an important soil in this area because of its small extent, being mapped in only two places in the county, near St. Marguerites and in the vicinity of Churchton.

The following table gives the results of mechanical analyses of the typical Sassafras silt loam:

*Mechanical Analyses of Sassafras Silt Loam*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21490..... | Soil..... | 0.2 | 1.6 | 6.3 | 6.9 | 11.0 | 52.2 | 21.6 |
| 21491..... | Subsoil ..... | .5 | 3.5 | 12.3 | 10.1 | 15.8 | 36.2 | 21.4 |

## THE SASSAFRAS FINE SANDY LOAM

The Sassafras fine sandy loam is of considerable importance on account of its large extent and its value as a general agricultural soil.

The surface soil, where typically developed, consists, to a depth of 8 to 10 inches, of a dull-brown medium to fine sandy loam, sometimes quite heavy and containing gravel. Some coarse sand is also usually present. In places, where the surface is only moderately rolling, considerable silt is present, giving the material a more loamy character and approaching more nearly the coarser more rolling phase of the Sassafras sandy loam.

The subsoil consists of a deep yellow or yellowish brown heavy sandy loam, becoming lighter in texture as depth increases, until at 26 to 30 inches it passes into a sand or loamy sand, varying in color from a light yellow to a reddish brown and containing in places considerable gravel and coarse sand.

In spots where poor drainage obtains both soil and subsoil are light in color and heavier, containing more silt than the more rolling areas. On steep slopes, especially near streams, the gravel content is often quite high. In places it exists in such proportions as to place this soil in the Sassafras gravelly loam type.

Both the surface and subdrainage of this soil are excellent. The loose, open character of the subsoil allows excessive moisture to pass readily through it, while at the same time the texture of the soil gives it a good water-holding capacity. Very little of this soil would be greatly benefited by artificial drainage.

This type will perhaps stand a greater range in seasonal conditions than any other in the area. It may be used for early or late crops without much danger of damage from drought or excessive rain. It is sufficiently sandy to permit being worked when quite wet and yet not so sandy as to cause crops to suffer from continued dry weather. When dry it does not become compact as do the heavier soils.

The material composing this type is a marine sediment derived from the higher lands farther north. The particles are sharp and angular, indicating that the soil has not been waterworn to a great extent. The fine-sand content is noticeably large in some parts of this type.

The Sassafras fine sandy loam occurs principally in the southern and western parts of the county, but is found in small areas in other parts. It occupies the more gentle stream slopes and rolling areas in the stream divides. It is found at elevations ranging from 40 to 150 feet above tide, and is closely associated with the Sassafras silt loam.

The Sassafras fine sandy loam of this area is truly a general-purpose soil, since almost any crop grown in this climate may be profitably cultivated on it. It is used here, however, principally for the growing of gen-

eral farm crops including corn, wheat, oats, rye, clover, tobacco, hay, and where near a cannery, for tomatoes. Water-melons, cantaloupes, beans, peas, and nearly all the vegetables may be successfully grown.

Peaches, apples, pears, plums, and cherries are grown to some extent and do well on this type, but the fruit industry has been greatly injured here by insect pests and fungous diseases. Small fruits are also well adapted to this soil, and it is an especially good soil for the production of strawberries.

This is one of the best tobacco soils in the county. On the lighter, more sandy phase the yield is good and the quality and color of the leaf is excellent. From 1000 to 1200 pounds is not an uncommon yield. Those who grow heavy crops always fertilize heavily with stable manure and commercial fertilizers. The ordinary application of manure is about 4 tons to the acre, with about 500 pounds of commercial fertilizer of rather high grade, the usual analysis being about 8–2–5. Some farmers in this county believe in growing tobacco on the same land continuously, as they say the quality of the leaf is better on old tobacco land and the yield, if the land is properly fertilized, will not decrease.

As a general thing the soil is quite deficient in vegetable matter, the ordinary application of barnyard manure not being sufficient to maintain a satisfactory content. Green crops should be plowed under or more live stock kept. An ideal way to enrich the land is to grow large amounts of forage and to keep a large number of domestic animals to consume it, applying the resulting manure to the soil. But not many farmers have sufficient stock to keep up the organic constituents of the soil in this way, and the next best thing to do is to plow under green crops.

The natural forest growth consists principally of pine, chestnut, tulip, beech, dogwood, maple, oak (several species), linden, black and sweet gum, hickory, locust, and persimmon, while a few ash, ironwood, aspen, and mulberry trees are found. Among the most prevalent small shrubs and bushes are sassafras, sumac, elder, blackberry, dewberry, raspberry, and wild plum.

The price of this type of farm land varies from $20 to $75 an acre, according to location, the average being about $40 an acre. In the

southern part the values are somewhat lower because of inadequate shipping facilities.

The following table gives the results of mechanical analyses of the soil and subsoil:

*Mechanical Analyses of Sassafras Fine Sandy Loam*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21482..... | Soil..... | 0.5 | 3.1 | 6.3 | 43.4 | 22.5 | 16.1 | 7.2 |
| 21483..... | Subsoil ..... | .0 | 2.3 | 4.3 | 24.6 | 28.9 | 19.5 | 20.2 |

### THE SASSAFRAS FINE SAND

The Sassafras fine sand is found principally in the southern part of the county. It exists here either as a terrace formation or as areas capping the highest hills and ridges. Along the western side of the county it occupies low-lying terraces along the Patuxent River as far north as Priest Bridge. A few isolated areas are found farther north and also in the extreme western part of the county, in the vicinity of Laurel.

The surface soil to a depth of 8 to 10 inches is a slightly reddish-yellow or light-orange medium to fine rather loose angular sand. This is underlain to a depth of 3 feet by a somewhat darker reddish-yellow sand, which is usually coarser than the surface material. At 3 feet below the surface the material is always loamy and in places it is quite heavy. The higher lying or hilltop phase has generally a more shallow soil. In some places the terrace areas consist of a loose deep sand several feet in depth.

The loose, open character of the soil to a depth of at least 3 feet allows the moisture to pass rapidly down, thus making the type unfit for the growing of such crops as corn or small grains. Tobacco is grown in considerable quantities and the quality is said to be very fine, but the crop often suffers from the effects of continued drought. In places on the ridges where the subsoil is not so far below the surface an ample supply of moisture is ordinarily maintained throughout the growing season. A liberal supply of vegetable matter in the form of barnyard manure or green crops plowed under aids materially in increasing the moisture-

holding capacity. Not much live stock is kept where this type is found, and for this reason stable manure is scarce, and the plowing under of such crops as cowpeas, crimson clover, velvet and soy beans is about the only practical method of increasing the organic matter content of this soil.

The Sassafras fine sand of this area is a typical truck soil, but it is little used for this purpose, because of situation in parts of the area where manure is difficult to secure, being too far from Baltimore, the principal source of supply, and also for the very important reason that markets and marketing facilities are not at hand. As soon as railroads penetrate the southern end of the county there is sure to be a marked development of the soil along several lines of special farming. Some fine crops of tomatoes are grown on this soil in localities near canneries.

The natural forest growth is principally pine, interspersed with several species of hardwoods.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

*Mechanical Analyses of Sassafras Fine Sand*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21470..... | Soil..... | 0.2 | 3.0 | 6.1 | 43.9 | 26.9 | 12.8 | 6.9 |
| 21471..... | Subsoil..... | .3 | 1.9 | 4.7 | 40.8 | 25.7 | 12.1 | 14.2 |

THE SASSAFRAS LOAM

The surface material of the Sassafras loam, to a depth of 6 to 10 inches, consists of a light brownish-gray or yellowish-gray silty loam, containing considerable fine sand and occasionally some gravel. The subsoil is a deep yellow heavy loam, approaching a sandy clay in places. The type is considered a heavy soil in this area. The content of fine sand, silt, and clay seems to be about the same. The soil resembles both the Sassafras sandy loam and the Sassafras silt loam, and it is therefore sometimes difficult to identify it. The topography is the most distinguishing characteristic. The surface of the sandy loam of this series is quite rolling,

while that of the silt loam is largely level, or nearly so. The topography of this type, the loam, is intermediate between the two and may properly be called billowy.

The type is not extensively developed in this area. The largest unbroken area occurs in the neighborhood of Millersville. It is rather a highland type, this area being at an elevation of something over 100 feet above tide. There are only a few other small isolated spots of the type in the county.

All crops common to the county are grown on this type with good results. At present much of the land is kept in grass as much of the time as possible. Corn, wheat, oats, potatoes, and truck thrive. Fruit seems to do especially well on this soil. Some very fine orchards of Kieffer pears and damson plums are situated near Millersville.

Some parts of the type are in need of drainage, but these are not usually large, the greater part of the land being sufficiently undulating and open to admit of good surface drainage and underdrainage.

The type is practically all under cultivation, the original timber growth having been removed. This is said to have comprised all of the species common to the moderately elevated and well-drained types.

Much of this type is owned by people of considerable wealth, and as the Washington, Baltimore and Annapolis Electric Line runs through the principal area, few farms are for sale. The average price of land of this class is probably as high as $60 an acre.

### THE SUSQUEHANNA SANDY LOAM

The Susquehanna sandy loam occupies some areas of more rolling topography in the northern and northwestern parts of the county.

The top soil, to a depth of about 8 inches, is a gray, medium to coarse light sandy loam, containing in some places considerable gravel. The subsoil becomes redder and heavier until at a depth of 15 to 25 inches it grades into the characteristic Susquehanna subsoil, which is a red to deep reddish-yellow or purple stiff impervious clay. In some small areas where the surface is nearly flat the top soil contains considerable silt and fine

sand, giving it a distinctly loamy character. Scattered throughout the subsoil and occasionally on the surface are various sized fragments of iron-cemented conglomerate.

Much of this type is still covered with the original forest growth, which consists principally of pine, chestnut, oak, hickory, black gum, holly and huckleberry.

The surface features are always rough and sometimes quite steep, so that where the forest is removed the soil is subject to severe erosion. In such cases the surface material has in many places been removed, giving rise to patches of typical Susquehanna clay too small to map.

On account of the impervious nature of the subsoil and the loamy character of the surface soil, the type has good moisture-holding capacity, and where properly cultivated good crops of wheat, grass, corn, and potatoes are grown. The appearance of the crops on this type indicates a strong, retentive soil capable of maintaining a constant supply of moisture throughout the growing season.

Some excellent orchards are found on this soil in the vicinity of Marley Station and Elvaton, on the Baltimore and Annapolis Short-line. Pears seem to be well suited to this soil. According to the testimony of some of the owners and to external indications, the fruit trees growing here are more healthy and more resistant to the attack of insects and diseases than on many of the other soils of the area.

Strawberries grown on this type are said to be sweeter and more highly colored; that they are firmer and therefore less subject to injury from handling there is no doubt.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

*Mechanical Analyses of Susquehanna Sandy Loam*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21498..... | Soil..... | 0.7 | 8.3 | 12.8 | 40.9 | 15.1 | 16.3 | 5.5 |
| 21499..... | Subsoil..... | 1.6 | 12.3 | 15.0 | 26.8 | 14.1 | 19.0 | 11.0 |

### THE NORFOLK SAND

The Norfolk sand occupies a considerable area in the northern part of the county. In an irregular way the type extends from about 2½ miles east of Jessup to the shore of the Chesapeake on Hog Neck. The most northern point of this area is near Shipley and it extends south to about 1 mile north of Severn Run. The area is irregular in outline and is divided into two sections by Marley Creek.

The surface soil of this type, to a depth of 6 to 10 inches, is a gray or yellowish-gray medium sand, with a loose and incoherent structure. The subsoil, to a depth of 3 feet and more, is a light-yellow, loose medium sand, becoming slightly loamy at a depth of 25 to 36 inches. In some places there is a considerable percentage of fine quartz gravel scattered throughout soil and subsoil.

The topography is rolling, but not steep or rugged, except where streams have cut deep gullies. In the deeper cuts the profile shows streaks of orange-colored and brown sand. Often layers of very white sand are found in the deeper parts of the profile. In some places, at depths not less than 12 to 15 feet, material similar to that giving rise to the Susquehanna clay is encountered. The depth to this clay, however, is so great that it has no effect on the crop-producing power of the soil. Above this clay there is no material that can act as a water-retaining layer, and the water-holding capacity of the soil is therefore very low. The sand is much cleaner and there is less coherence between the constituent particles than in the case of the Sassafras sand. Crops must be planted early and harvested before dry weather sets in. Crops are often lost because dry weather comes before they are ready for gathering.

This type is in great demand for trucking purposes, and practically all of it is under cultivation. For the light early truck crops it is perhaps the best type in the area. The loose, light nature of the soil and the readiness with which it warms up in the spring favors very early maturity. Water-melons, cantaloupes, cucumbers, eggplants, and peas thrive. For all crops large quantities of manure and commercial fertilizer are used, as much as 25 to 30 tons of stable manure and 500 to 700 pounds of

fertilizer being applied to the acre. This excessive feeding of the soil is necessary every year. No matter how liberal the application, the manure almost entirely disappears before the following season's crops are planted. Small fruits, particularly dewberries and blackberries, do well. Peaches are grown with considerable success, but the trees are short lived on account of the severe droughty conditions to which they are often subjected.

The type is not well adapted to the general farm crops on account of its low water-holding power. In seasons of ample and well-distributed rainfall some fine crops of corn have been grown, but this is not common.

All of this soil is within easy hauling distance of Baltimore, and therefore highly prized. Practically all the truck from this type is taken to market in wagons, and large quantities of stable manure are brought back from the city.

Below are given the results of mechanical analyses of samples of the soil and subsoil:

*Mechanical Analyses of Norfolk Sand*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21458..... | Soil..... | 1.3 | 22.7 | 26.6 | 33.2 | 6.4 | 4.1 | 5.2 |
| 21459..... | Subsoil ..... | 1.1 | 18.5 | 26.0 | 41.5 | 6.5 | 4.2 | 3.3 |

## THE SASSAFRAS SAND

The Sassafras sand is a soil which has been mapped under other names in some other areas. It was called Norfolk sand, but now it seems necessary to separate it from the Norfolk series on account of color, composition, and other important differences. This sand apparently has not been reworked to a sufficient extent to make it as pure and uniform a sand as the Norfolk. Its composition is more complex and the oxidation of its iron content is not so far advanced. Layers of very pure white sand are often found 18 to 20 feet below the surface. Such deposits are extensively mined near Whitneys Landing.

The surface material of this type, to a depth of 6 to 10 inches, is a grayish-yellow to brown sand, frequently of a somewhat loamy texture. The subsoil is a yellowish-red or brownish rather loamy sand, becoming redder as greater depths are reached. The lower subsoil is quite often close to a sandy loam in texture. There is a moderately high content of coarse sand and often considerable gravel in both soil and subsoil, and ironstone plates and iron-cemented conglomerates are found in varying quantities throughout the soil and subsoil to such an extent in places as to prevent it being used for farming purposes.

The topography is in part hilly, with the greater part ranging from billowy or undulating to rolling. Both surface and subdrainage are so thorough and rapid as to cause crops to suffer severely from the effects of continued drought.

The Sassafras sand is found principally in the central part of the county, extending from well down on the shores of the Magothy River westward to near the county line in the vicinity of Annapolis Junction. Other small areas are found in the extreme northern and western section.

In this county the Sassafras sand is a trucking soil of considerable importance, but it is not used for that purpose to such an extent as the Norfolk sand, largely for the reason that most of it is farther away from market. Much of it also has an uneven surface and is covered with loose fragments of conglomerate and ironstone to such an extent that it will probably not be used for agricultural purposes until all the better-lying land free from stones has been brought under cultivation.

The highest development of this type as a trucking soil is found on the east shore of Marley Creek and in the region of Earleigh Heights, Pasadena, and Elvaton; also in the vicinity of Odenton and northward. In these localities the type is gently rolling, free from stone, easily cultivated, and sufficiently close to market, so that crops are easily produced and disposed of. On these more level areas trucking is carried on in its most intensive form. The loose, open nature of the type makes imperative the yearly application of large quantities of manure and commercial fertilizers. Profitable crops of cantaloupes, water-melons, tomatoes, egg-

plants, peas, beans, and strawberries are grown. Large quantities of tomatoes are packed at the cannery at Odenton and many are shipped or hauled to the Baltimore markets.

The Sassafras sand of this area is well adapted to the growing of fruit. Peaches, early apples, and pears do fairly well and this season (1909), although a very dry one, there is a good crop of some varieties of apples and of Kieffer pears on the trees.

The following table gives the results of mechanical analyses of fine-earth samples of soil and subsoil:

*Mechanical Analyses of Sassafras Sand*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21468..... | Soil..... | 1.8 | 16.4 | 21.9 | 34.7 | 7.3 | 9.8 | 7.9 |
| 21469..... | Subsoil..... | 1.6 | 12.9 | 18.5 | 36.5 | 8.1 | 11.2 | 11.3 |

## THE SASSAFRAS LOAMY SAND

The Sassafras loamy sand is closely associated with the Sassafras sand and is found included within the boundaries of the latter soil. It occupies the higher and more nearly level areas where the less active erosion has not removed so great a proportion of the finer constituents.

The surface soil is a reddish-yellow to brownish medium loamy sand to a depth of 12 inches, usually becoming somewhat lighter in color and more compact at the above-named depth. At 26 to 30 inches rock fragments are usually encountered, sometimes the proportion being so high as to prevent boring. Below this stony layer there is sometimes a layer of lighter-colored medium sand several feet in thickness. Occasionally the lower portion is a sandy loam.

The type is not of great importance in this area, being found only in a few small areas, principally near the headwaters of the Severn River north of Whitneys Landing. Another area of considerable size lies north of Burns Crossing, on the Washington, Baltimore and Annapolis Electric Line. The areas north of Whitneys Landing are not at present under cultivation.

On account of the loamy nature of the soil it is much more retentive of moisture than the Sassafras sand. Where under cultivation, it produces very satisfactory crops of truck as well as good yields of corn and hay. The principal hay crop on this type is made from crab grass.

The natural forest growth is practically the same as that on the Sassafras sand, and consists principally of pine, chestnut, oak, hickory, tulip, dogwood, and holly.

Below are given the results of mechanical analysis of a fine-earth sample of the soil:

*Mechanical Analysis of Sassafras Loamy Sand*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21478..... | Soil..... | 2.6 | 18.9 | 30.9 | 18.6 | 7.6 | 14.7 | 6.6 |

## THE SUSQUEHANNA GRAVELLY LOAM

The soil of the Susquehanna gravelly loam, to a depth of 6 to 8 inches, is a pale yellowish-gray medium sandy loam, containing a large percentage of well-rounded gravel. This is underlain in many places to a depth of several feet by almost pure gravel or sandy gravel. Below the gravel is uniformly found the characteristic clay, which underlies all the soils of the Susquehanna series. Scattered over the surface and throughout both soil and subsoil are large quantities of ironstone fragments and conglomerate. Except where the gravel is deep the clay comes to within 3 feet or less of the surface.

The type occupies the higher hills and steep valley slopes of the northwestern part of the county, the largest single area being in the vicinity of Ehrmansville. A short distance east of Laurel is another area of considerable size. Other small strips and spots are found in various parts of the northwest section of the county.

Agriculturally this type is of small importance. Much of it is too rough and steep to admit of cultivation, and where such is not the case the

amount of loose rock fragments is so great as to make cultivation difficult and unprofitable. Very little of it is now under cultivation, and the crop yields are low. It is a nonagricultural soil and should be left in forest.

Several extensive gravel pits are worked in this type in the county.

### THE SUSQUEHANNA SAND

The Susquehanna sand is a type which might be termed an intermediate soil between the Sassafras sand and the Susquehanna sandy loam. It has a subsoil of heavy clay sufficiently close to the surface to prevent its being called Sassafras sand, and yet at such a depth that it cannot be called Susquehanna sandy loam. In some places the clay is quite deep, but the overlying sand is of such a bright red color as to throw it out of the Sassafras series.

The surface material to a depth of 6 to 8 inches is a pale reddish-yellow or pink, mealy, loose, medium sand. The subsoil is a light red, loose, mealy sand, usually becoming sticky and mottled somewhere between 20 and 36 inches beneath the surface. Stiff, mottled clay is encountered ordinarily at depths ranging from 24 inches to 4 or 5 feet.

The surface features very from gently rolling to quite level. A few small areas form the summits of low hills. It is found only in the northeastern part of the county near the Patapsco River.

While on account of its small extent this is not an important soil in the county, it is, when properly handled, a good trucking and fruit-growing soil. One of the best peach crops in the county this year (1909) was produced on this type. The clay is in many places sufficiently near the surface to make the soil quite retentive of moisture, so that some long-season crops like corn and tobacco produce good yields, even in dry seasons. The roots of crops on this soil extend deep into the soil without difficulty, and for this reason crops are better able to resist the effects of continuous dry weather than on some of the heavier soils.

A few well-kept and profitable farms on this type in the vicinity of Nabbs and Cox creeks show the possibilities of this soil. The incorporation of organic matter, either in the form of green crops plowed under or stable manure, is of great importance.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

*Mechanical Analyses of Susquehanna Sand*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21494..... | Soil..... | 0.3 | 10.2 | 19.4 | 29.8 | 14.5 | 18.0 | 7.3 |
| 21495..... | Subsoil ..... | .0 | 10.7 | 22.2 | 35.5 | 11.0 | 10.9 | 9.6 |

## THE SUSQUEHANNA CLAY LOAM

To a depth of 5 to 8 inches the soil of the Susquehanna clay loam is a compact yellowish to light-red clay cloam, becoming redder and much heavier in the lower part. The subsoil, beginning at from about 6 to 15 inches, is a stiff, plastic, deep-red or mottled, heavy, impervious clay. The mottlings are yellow, light gray, or purplish.

This type is found only in small patches scattered over the northern part of the area and is of almost no importance agriculturally. No attempt should be made to farm this soil. The topography varies from steep, eroded slopes and gullies to nearly flat areas, the latter having a silty, chalk-like top soil. On the steep slopes erosion has exposed the barren, raw clay.

The subsoil of this type is a good brick and tile clay and is used to some extent for this purpose. The following table gives the results of mechanical analyses of the soil and subsoil of this type:

*Mechanical Analyses of Susquehanna Clay Loam*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21500..... | Soil..... | 0.4 | 16.7 | 15.0 | 15.1 | 7.3 | 28.8 | 17.2 |
| 21501..... | Subsoil ..... | .4 | 7.3 | 6.6 | 6.2 | 3.1 | 44.9 | 31.3 |

## THE ELKTON SILT LOAM

The Elkton silt loam is found mainly on the flat foreland areas in the southern part of the county along the Chesapeake Bay, though a few

small areas are mapped near the shore of the Chesapeake between the Severn and Magothy rivers.

The surface material of this type is a light pale-gray silty loam, slightly mottled with light yellow in the lower layers. This material extends to a depth of 5 to 7 inches, where it rests upon a light-gray silt loam, highly mottled and quite heavy, which extends to considerable depth. Below this in some places is found a soft glauconitic material. The surface of this type is almost flat. This fact, coupled with the close, compact nature of the soil, is responsible for very poor drainage conditions.

Crops on this soil seem to suffer both in wet and dry seasons. When rains are in the least excessive the crops are flooded, and in dry seasons the plant roots are unable to draw sufficient moisture from the close, retentive soil, although the moisture supply is relatively large. These conditions are corrected to some extent by open ditches. Subdrainage, however, is not successful on account of the impervious nature of the soil. Most of this land was at one time quite thoroughly drained with surface ditches and good crop yields were secured. It is said that thirty to forty years ago as much as 40 bushels of wheat per acre were produced on this soil in the neighborhood of Churchton. Tomatoes grown on the Elkton silt loam are firmer than on many of the other soils and therefore much better for shipping and canning. They bring a higher price than those produced on any other type in the area. Some fruit is produced. The soil is, however, a typical grass soil, and stock raising and dairying are branches of farming that could perhaps be most profitably developed upon it.

Farming on the Elkton silt loam has been very much neglected in the last twenty-five years because of the development of the oyster industry. At this business a man can earn from $3 to $5 a day from September to April, which is much more than the farmer of ordinary resources can realize from farming. Most of the people grow a few products for their own use, and some have a small amount to sell. There are a few well-tilled farms in this section, but they are principally located on the slightly higher portions.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

*Mechanical Analyses of Elkton Silt Loam*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21454..... | Soil..... | 0.0 | 0.2 | 0.2 | 0.7 | 3.7 | 78.6 | 16.6 |
| 21455..... | Subsoil..... | .0 | .0 | .4 | .8 | 7.6 | 65.7 | 25.9 |

## THE SASSAFRAS SANDY LOAM

The Sassafras sandy loam closely resembles the Sassafras fine sandy loam in every respect except texture and possibly agricultural value, although it is considered a very good soil for general farming purposes. It is doubtless a somewhat better tobacco soil than the type of finer texture.

The type occupies about the same position as regards elevation as the Sassafras fine sandy loam and is found only in the northern end of the county. It is a good farming soil, but is unimportant because of its small extent.

Good yields of wheat, corn, tobacco, cowpeas, and clover are grown. It is also an excellent soil for the kinds of fruit suited to the region, as it usually occupies an elevated position, thus reducing the danger from killing frosts.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

*Mechanical Analyses of Sassafras Sandy Loam*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 21479..... | Soil..... | 1.9 | 13.0 | 15.6 | 23.7 | 15.2 | 22.4 | 7.8 |
| 21480..... | Subsoil..... | 1.6 | 1.3 | 14.2 | 33.7 | 9.8 | 27.7 | 11.6 |

## THE SASSAFRAS GRAVELLY LOAM

The Sassafras gravelly loam occupies much of the bottom land and terrace slopes along the Little Patuxent River and its tributaries. In

the extreme northern part of the county, near Brooklyn and Curtis Bay, some extensive areas of this soil also occur. Other small areas exist in various parts of the northern half of the county. The steeper phase of the type is rough and not well suited to farming. The valley phase is quite level and is used extensively for agricultural purposes.

The surface soil to a depth of 6 to 10 inches is a dark-gray gravelly sandy loam, becoming lighter in color as the percentage of organic matter decreases with increase in depth. The subsoil to 36 inches and beyond is a light yellow sandy gravel. In some places conveniently located this material is mined for concrete and road construction.

On the valley portions of the type good crops of corn, hay, cowpeas, tobacco, sweet potatoes, and fruit are grown. In the vicinity of Woodwardville some particularly well cultivated farms are found. Although the subsoil is open and porous and crops often suffer from drought, the effects of dry weather are not noticeable on this type as quickly as on some others. The reforestation of the steeper areas is recommended, on account of their low agricultural value. The natural forest growth consists of pine, chestnut, and oak.

### THE COLLINGTON GRAVELLY SANDY LOAM

The Collington gravelly sandy loam is not of great importance in this area, on account of its small extent and the uneven stony nature of its topography, which makes it difficult to cultivate.

The type exists as steep hillsides along the margin of the Collington sandy loam areas. On the south shore of the Magothy River this type occurs as low hills and terrace walls. In other places it occurs on steep, short slopes separating the higher lying Sassafras soils from the low-lying types along the water front.

The top soil, to a depth of 10 to 15 inches, is a medium sandy loam, grayish to reddish brown in color, containing a large percentage of various sized quartz gravel and ironstone fragments. The subsoil consists of a greenish-yellow to reddish-yellow sandy loam or sandy clay, containing considerable gravel and ironstone and much greensand, which gives it the typical color of the Collington soils.

About the only use to which this soil is adapted is peach growing, and although the land is difficult to cultivate the trees thrive especially well and produce fruit of very fine flavor and color. The rough, stony character of the surface makes it difficult to keep the orchard free from weeds and grass—a condition which usually results in short life to the trees. However, peach growing on this soil has proved profitable.

### THE MEADOW

The soil mapped as Meadow is confined entirely to margins along streams, and to a few small areas in the lower portions of the foreland near tide water. The areas along the stream courses are very narrow, except at points of confluence and at the heads of streams where there is a broadening of the areas.

The character of this land varies with that of the soil of the drainage basin of the stream. In sandy sections the Meadow areas are deposits of almost pure sand mixed with partially decayed organic débris. In the sections of the county with heavier soils the Meadow has somewhat the same heavy character as the surrounding types.

Almost all of this Meadow land is subject to occasional overflow, and it is therefore used only for grazing purposes. Much of it is covered with a dense growth of trees and underbrush, consisting principally of willow, birch, sweet gum, soft maple, sycamore, and water beech, with various weeds, vines, and coarse grasses.

If diked and drained this soil in many places would be very productive, and in case of some of the more extensive areas along the larger streams reclamation would no doubt be profitable.

### THE TIDAL MARSH

Tidal marsh comprises the low, flat, marshy areas along the Chesapeake Bay which are subject to daily inundation by tide water. There is only a very small area of the type; too inconsiderable to warrant the construction of dikes for its reclamation. It supports a dense growth of coarse salt-marsh grasses. There are occasional narrow strips too small to be shown on the map.

FIG. 1.—VIEW SHOWING FARM AND WOODLAND ALONG SOUTH RIVER.

FIG. 2.—VIEW OF WATERMELON PATCH, SHOWING FERTILITY OF POTOMAC SAND, NORTH OF MAGOTHY RIVER.

## THE AGRICULTURAL CONDITIONS

Anne Arundel has been an agricultural county since its first settlement. Tobacco and corn were grown by the Indians before the white man came. Owing to the splendid markets close at hand the agriculture of the county has changed radically in the last 25 years from general farming to trucking. The Chesapeake and its tidal tributaries furnish excellent shipping facilities.

The southern part of the county has a variety of soils, some of which are well adapted to the growing of truck, but the poor railroad facilities of that section have hindered the development of the trucking industry. General crops are most largely grown there.

In the northern part the truck-growing business has had a remarkable development, due to the nearness of large markets to which products may be hauled by wagon, the adaptation of the soil to the purpose, and the unfailing supply of stable manure.

The climate is temperate. The rainfall is ample and usually well distributed throughout the growing season. Protracted droughts occasionally do some injury to crops, but destructive hail and wind storms seldom occur.

The soils of the county all belong to the Coastal Plain province. These are grouped in five series. The most important general farming types are the Sassafras fine sandy loam, the Sassafras silt loam, and the Collington sandy loam. The trucking soils of the county are the Norfolk sand and Sassafras sand. The Susquehanna sandy loam is a fairly good soil for general farming, and is a splendid soil for peaches, as well as for some varieties of apples, pears, and small fruits.

Practically all the soils of the area are deficient in organic matter. At present the greatest needs of the county are the more general practice of systematic crop rotation, the plowing under of more green crops, such as crimson clover and cowpeas, the more extensive use of improved farm machinery, and the keeping of live stock in the general farming sections.

In the trucking sections a large amount of money is expended for commercial fertilizers and stable manure. This expenditure might be greatly reduced by the growing and plowing under of more green crops.

The growing of peaches may well be extended and the growing of some varieties of apples, summer and fall sorts, pears, and small fruits can also be developed to advantage on suitable soils where market conditions are good. Modern methods of orcharding must be employed, however, to insure success.

The quality of the products grown in the trucking sections is most excellent, due in large measure to the sharp competition which always exists in such industries in close proximity to cities like Baltimore and Washington. Many of the farmers living in the sandy sections of the county grow truck almost exclusively, except where fruit is still grown. The principal crops are English peas, snap beans, lima beans, asparagus, cucumbers, cantaloupes, watermelons, squash, especially the bush scalloped, eggplant, tomatoes, and sweet potatoes. In the same section small fruits, including strawberries, dewberries, blackberries, and raspberries are grown extensively. Some peaches are also grown in the sandy sections.

General farming is the prevailing type of agriculture in the southern portion of the county, corn, wheat, hay, oats, tobacco, and potatoes being the most important crops. Corn is planted in checks usually about 3½ feet apart each way. Cultivation is done too generally with a one-horse plow that frequently runs too deep, breaking up the root system. Harrows and cultivators could be profitably used to a much greater extent with a saving of labor and better results.

Very little commercial fertilizer or manure of any kind is used for corn. More attention should be given to the manurial requirements of the crop, particularly with a view of supplying the soil with organic matter which can be done in a profitable way by turning under crops like crimson clover and cowpeas. Barnyard manure is a very effective manure for this crop and as much as possible should be produced on the farms. Commercial fertilizers are also used for corn by successful farmers in various parts of the state on soils very similar to those of Anne Arundel County.

The matter of seed selection is a very important one and should be practised more generally and with more care. No particular varieties are grown, but each farmer saves seed from his crop, selecting of course, the best ears. This is usually done after the corn is harvested and stored. The better plan is to select the seed in the field, where the good qualities of the stalk as well as the ear can be taken into consideration. New and well-selected varieties are seldom introduced, although there are in this part of the state some farmers who are making a specialty of seed-corn production.

The best soils in this area for corn are the sandy loams, silty loams, and well-drained bottom lands. Too many farmers grow corn on deep sandy soils of low water-holding power. The yellow or white dent varieties are best suited to the climate and other conditions of this county. It is not necessary or best to obtain seed corn from a distance. It should be produced in the neighborhood, or better, on the same farm where the crop is to be grown.

Tobacco has been grown in the county since its first settlement. The total amount produced has varied greatly at different periods, the largest yield in the history of its production having been made in 1860. The product grown here is practically all exported to Europe. The seed is sown in February in plant beds located on new ground, preferably a moist sandy loam, well protected from winds and covered with cloth. A few days before setting the plants they are left uncovered in order to make them more hardy.

The plants are set as soon as the weather permits in hills spaced about 4 feet each way. After the crop is well started, cultivation should be shallow, as deep plowing interferes with the root system, checking the growth. The land should be kept as nearly level as possible and not ridged during cultivation.

Topping should be more widely practiscd to insure a larger and better leaf. The best growers are all of the opinion that severe topping is advisable. When ripe, the plants are cut off near the ground and hung on sticks in the barn to cure. Flue curing has not proved very suc-

cessful from the standpoint of profitableness. When the leaves are cured they are stripped from the stalk, made into hands of uniform grade and packed into hogsheads to be sold.

The crop is heavily manured, and large amounts of commercial fertilizers are used. Potash has proved very beneficial to the crop and is generally applied in liberal amounts. A leaf of better quality is secured where the sulphate rather than the muriate of potash is used. Cover crops of crimson clover or cowpeas should be grown to increase the content of organic matter.

Much trouble has been experienced in getting good stands of the hay crops generally grown. Timothy does not seem to do well here on any of the soils. Redtop and some other grasses have been tried but with slight success. Orchard grass probably does best in this locality. Red clover does fairly well and is quite largely grown. Alfalfa has been tried in all parts of the area, but it has not been a success, except in the vicinity of Annapolis on the Collington sandy loam. Better results with alfalfa would likely be had by thorough preliminary preparation of the soil following a clean cultivated crop, liberal applications of burnt lime, and soil inoculation.[1] The soils generally are in need of lime, and it is believed that an acreage application at least 2000 pounds of burnt lime would prove a decided advantage as a preliminary treatment for all the hay crops.

Wheat and oats would prove more profitable crops if grown in systematic rotations, especially with legumes such as cowpeas and crimson clover. Wheat usually does very well after tomatoes. Various crops can be made to fit in excellent rotations, including wheat and oats, an essential factor being the production of those crops that supply organic matter.

Irish potatoes are grown to some extent on nearly every farm. Where they are grown on a commercial scale good yields are produced. The soil is always highly manured and well cultivated. Commercial manures are used scantily in a few cases where stable manure cannot be had. Irish potatoes do best on rich sandy loams well supplied with organic matter

[1] See Farmers' Bulletin No. 339, U. S. Dept. of Agr.

and well drained. If the soil is heavy the tubers are soggy; if light and sandy the crop is liable to suffer for want of moisture. The soils of the southern part of the county are well adapted to this crop and the industry should be more extensively developed. A good yield of Irish potatoes in this county is 200 to 250 bushels per acre.

Crop rotation is a subject which should receive more attention. It is practised to a certain extent, but too generally as a matter of convenience. The following is practically the only crop-rotation system in vogue: Corn is planted on sod land and wheat, if grown, is sown on the corn land in the fall without plowing. Grass is sown with the wheat, and clover is put on the same field in the early spring. The field is left in grass and clover for two years, when it is again plowed and planted to corn. Clover and grass are often sown on the corn land alone, as some farmers believe it does better without a nurse crop. This is a good rotation and will improve the land if carefully and continuously practised.

A crop-rotation system should include at least one leguminous crop, and more than one where practicable. There should also be a cultivated crop, such as corn, tobacco, or tomatoes, which should be followed by one of the small grains. A good rotation for a large proportion of the soils of the county, especially land in poor condition, is corn followed by crimson clover the first year, cowpeas followed by winter oats the second year, and clover the third year.

Modern farm machinery should be more generally used. The present prevalent method of cultivating crops with one-horse plows should give way to improved implements like the riding cultivators, by which such work can be done better, easier, and cheaper. A machine will often save the price of a hired man, and at this time, when farm labor is scarce and wages high, this becomes an important subject.

Fruit has been grown in this county since the first settlers arrived. The planting of peach and apple trees was one of the first things to occupy their attention. Until a comparatively few years ago satisfactory yields of fruit were obtained, though the orchards received no attention except at fruit-gathering time. This condition has been radically changed by

the multiplication of insects and diseases peculiar to fruit trees. It is now impossible to grow fruit without giving careful attention to cultivation, pruning, and spraying. Very few farmers, however, have given any attention to the control of such pests, and the result is that the fruit industry has declined.

In the last ten years a few have recognized that some kinds of fruit can be grown to advantage on the soils of Anne Arundel County, and have set orchards of apples, pears, principally of the Kieffer variety, and some peaches. Such orchards are regularly pruned and sprayed, and where the land will permit the orchards are cultivated. Some of the orchards, however, are on rather stony land where cultivation is difficult. Kieffer pears do especially well in the county, and for a limited amount of this variety there is a fairly good demand in the markets. The southern part of the county is especially adapted to the growing of pears, peaches, and some of the early varieties of apples.

Lately, the advisability of setting out peach orchards has been considered somewhat questionable on account of the prevalence of the yellows, a disease which cannot be controlled by spraying. The only known method of keeping the disease in check is by uprooting and burning all infected trees, but this to be effective must be under state control. Other diseases and most of the insect pests may be readily controlled at moderate expense by thoroughly spraying the trees with Bordeaux mixture and other fungicides and insecticides.

The use of stable manure is of such great importance in this area that it cannot be passed over without special mention. No figures are obtainable as to the total amount of manure used in the county every year, but some idea of the great quantity employed may be had when we consider that an annual average application of one-half to one carload, and sometimes more, is used to the acre by the great majority of truckers. The cost of stable manure alone amounts to as much as $3000 or $4000, or even $5000 a year for individual truckers. Much of the manure is shipped by boat to the farmers who live near tide water. It is being shipped continually from Baltimore and Washington and unloaded in vast piles

or ricks along the tracks or wharves, or hauled from the city direct to the farms, where it is worked over and given careful attention until needed.

The acreage application of manure seems to be increasing gradually with the best farmers. In late years barnyard manure is being supplemented with commercial fertilizers. High-grade mixtures are used in many cases at the rate of 500 to 700 pounds per acre.

The total amount of manure shipped into the county every year is so great that the reduction of this amount by only a small percentage would mean a saving annually of many thousands of dollars to the county. One way of accomplishing this is to grow and plow under more green crops. This is now practised by some farmers with satisfactory results. They grow cowpeas or crimson clover between the rows and plow them under while green. This is an excellent practice, and while it will not take the place of manure altogether, it will reduce the amount required to produce a good crop. In the trucking sections of the county this is about the only practicable method of increasing the organic matter content of the soil, aside from stable manure.

In the general farming sections of the county more manure should be made on the farm by keeping more live stock and carefully preserving all waste products. Too often the manure is thrown out under the drip of the barn, where a great part of its value is soon lost. It should be placed in a shallow basin-shaped depression into which the water cannot drain and the stock allowed to trample over it. The water falling on it as rain will be about sufficient to keep it in a good moist condition. If some provision is not made to prevent the deterioration of the manure, the best plan is to haul it direct from the stable to the fields while still fresh.

At one time stock raising was of considerable importance in Anne Arundel County. Twenty-five or thiry years ago nearly every farmer in the county, except possibly some in the sandy parts where trucking was carried on, kept more or less live stock, including cattle, sheep, hogs, and horses, and every year there was a surplus for sale. Some farmers at that time had as many as 1000 head of sheep. Changes in economic conditions later caused a rapid decline of the live stock industry. Now it is

unusual to see sheep in the area, and only enough hogs, cattle, and horses are kept to supply the needs of the farm. There are a few dairies in the county, which seem to be profitable, as the market for dairy products is never oversupplied. At the present time the conditions in the county, especially in the southern part, would seem to favor the production of live stock for market. The southern part is in many respects a typical stock-raising section; the soil is well adapted to the various grasses and other forage crops, and the pastures are well supplied with water.

In many respects the agriculture of Anne Arundel County reached a high state of development about the close of the last century. Since then there has been a decline in some lines of endeavor. According to the twelfth census the total acreage in farms, the number of acres in improved farms, and the percentage of farms worked by the owners were less in 1900 than in 1890. The average size of farms had decreased from 146 acres in 1880 to 124 acres in 1890, and to 109½ acres in 1900. In this respect there has been an improvement, a small farm being usually better worked than a large one. The value of land and improvements, of implements and machinery, and of live stock was less in 1900 than in 1890 and, with the exception of implements and machinery, was even less than in 1880. The value of all farm products in 1900 was $1,882,241, being greater than at any time since 1879. This probably is due to the marked development of the trucking industry. The expenditure for fertilizers has steadily increased from $110,518 in 1879 to $183,970 in 1900, which also doubtless follows as a result of the increase in market gardening and trucking. The production of the cereals has decreased since 1880, except in the case of corn, which has slightly increased since 1890. While the yield of Irish potatoes has decreased since 1890, that of sweet potatoes was much greater in 1900 than ever before. This is because the sweet potato is grown as a trucking crop.

With the exception of asparagus and a few other crops of less importance, garden peas and snap beans are the first garden products to reach the market. Anne Arundel, if not the largest producer, is one of the most important counties of the country in the production of garden peas. A large part of the crop is canned within the area.

Peas are planted as early as the soil and weather conditions will permit; beans are planted a little later. The low-growing dwarf or bunch varieties are grown mostly for the reason that they do not require supports.

Heavy applications of well-rotted barnyard manure are applied to these crops, and especially to beans. Some growers believe that both crops do best on soil which has been heavily manured the previous year and none applied at the time of planting. The rows are usually planted in pairs and every alternate row is made wide, about 3 feet, to facilitate picking. Cultivation should be shallow.

These crops unless properly cared for are liable to considerable damage from the attacks of insect pests and diseases, among which anthracnose, powdery mildew, blight, and rust are prominent. By the use of insecticides and spraying Bordeaux and by persistent seed selection, injury from this source can be reduced to a minimum.

The growing of cantaloupes is one of the leading special industries of the county. A desire to get the melons to market early has led the growers to adopt various methods of hastening growth. The seed is planted in March in tin cans containing a mixture of manure, sod, and occasionally stream alluvium, all thoroughly rotted by winter composting. The cans are placed in glass-covered cold frames and early in May the plants are set in the field without disturbing the roots. In this way there is little or no check to the growth of the plants and the maturity of the melons is advanced considerably. By this method cantaloupes can be marketed two weeks earlier than where the seed is planted in the field. The method, however, is expensive, and only a few acres for extra early market are handled in this way. The Knight is the principal variety grown. Other sorts, such as Jenny Lind, Hackensack, Anne Arundel, and Delmonico, are planted to some extent. The Rocky Ford does not seem to be particularly well suited to the conditions here.

In seasons of protracted drought following wet weather the melon crop sometimes suffers severely from leaf blight, and many acres were practically destroyed by this disease during the season of 1909. Leaf spot and anthracnose are other diseases to be contended with in the growing of

cantaloupes. As in the case of garden peas and beans these enemies can be controlled by spraying with Bordeaux or some other of the standard fungicides.

The cantaloupe industry is quite profitable in favorable seasons. From 500 to 700 baskets per acre are ordinarily secured, and yields of 1000 baskets have often been produced. The melons sell for 25 to 45 cents a basket. The early transplanted melons bring a higher price. The crop is not an expensive one to grow, requiring very little hand work and easily gathered.

The growing of tomatoes is one of the most important and extensive industries in the area. The crop is grown in all parts of the county upon a number of different soils and with varying results. Best results are had upon the sandy loams and loams of the Sassafras and Elkton series. Having a high sand content and good drainage the soil warms up early, inducing rapid development and consequently early crops. Canneries have been conveniently established in various sections of the county for handling the surplus crop. The output of some of these canneries is very large, this being an important industry. In the southern part of the area a considerable part of this crop is shipped by boat to Baltimore, the surplus of course going to the canneries.

Liberal applications of stable manure are made to the tomato fields before setting the plants, and most farmers apply various amounts, usually 200 to 500 pounds per acre, of a high-grade commercial fertilizer after the plants are in the field. Tomatoes do very well following some highly manured cultivated crop. They also do well after clover. To obtain the best results the soil should be well supplied with organic matter. The amount of commercial fertilizer required for good results can be materially reduced by growing the legumes, particularly clover, and by liberal use of barnyard manure. Where the condition of the soil is not the best it is a good plan to apply a large quantity of stable manure, followed with about 500 pounds of fertilizer containing a high percentage of nitrogen potash.

In the trucking sections, where an early crop is the object, the plants are supported by stakes and sometimes pruned, a practice which will often cause the fruit to ripen several days earlier than where the vines lie on the ground. In general field culture, however, the plants are not supported, especially where the fruit is grown for canning.

The most careful growers select the best and most perfect fruits for seed. In this way they are able to produce not only a fine tomato but one of such color and size as the market demands. This is a commendable practice, and should be adopted by all growers, not only with tomatoes but other crops, like cantaloupes.

The plants are grown in cold frames under glass, some growers transplanting them once before setting. This should always be done where practicable, because it gives the large, sturdier plants essential for the best results. Tomatoes are not greatly troubled by disease or insect enemies. Occasionally some damage is done by the tomato worm.

Cucumbers are quite largely grown in the trucking sections of this county. The soil best adapted to their requirements is much the same as that suited to the cantaloupe; that is, a well-drained sandy loam overlying a sandy clay subsoil. Cultivation also is about the same for the two crops, as are also the means necessary to combat troublesome insects and diseases. Considerable loss comes from the dying out of vines following the ripening of fruit. If no cucumbers are allowed to ripen, the vines continue to produce fruit for a much longer time.

Watermelon culture is deserving of special mention on account of the large number grown in the area and the fine flavor and quality of the product. Watermelons are grown in all parts of the county, but mainly in the trucking section between Baltimore and Annapolis. They do best on sands or deep, well-drained sandy loams. For an extra early crop the fields should have a southern exposure. A few aiming to supply the early market grow the plants under glass and transplant to the fields. Under prevailing methods of culture liberal application of barnyard or stable manure is made either in the hill or continuously in the row. The manure should be well mixed with the soil before planting. It is generally

considered that the crop cannot be grown profitably with the use of commercial fertilizers alone, some even claiming that mineral fertilizers should not be used at all. Most planters, however, use some fertilizer, though depending mainly upon barnyard and stable manure. Many farmers have ceased to grow melons on account of not being able to secure manure. Cowpeas are sometimes grown between the rows and worked into the soil during cultivation, in this way maintaining the organic-matter content of these soils and lessening the need of barnyard manure. Watermelons require only a moderate amount of cultivation and care, and always find a ready market. Large numbers are hauled by wagon to Baltimore and Annapolis, and many are shipped by water to various parts of the county. The most popular variety is the Kolb Gem; Kleckstock, Peerless, and Rattlesnake are also grown.

Sweet potato culture is an important industry in the county. The crop is grown in all parts of the area, but most extensively in the trucking region south of Baltimore. The light sandy soils are best adapted to their production, although heavy yields are produced on the sandy loams and loams. They are apt to be discolored if grown on heavy red soil, like the Susquehanna clay loam. Sets are grown from tubers placed in a hotbed in the early spring. From 5000 to 8000 plants are required for each acre. Well-rotted barnyard manure is applied in large quantities to this crop, and a liberal application of commercial fertilizer high in nitrogen and potash is also given.

Sweet potatoes are commonly sold directly from the field, but for later market and seed some are stored in cellars or piled in the field and covered with straw and then with earth. Three hundred bushels per acre is considered a fair crop. The most popular varieties are Red Nose, Early Carolina, and Red Nansemond.

Next to the trucking industry in importance is the growing of small fruits, of which strawberries are by far the most important. More strawberries are grown in Anne Arundel than in any other county in the state. Although much hand work is required in cultivating and harvesting the crop, it is usually quite profitable. The larger yields are secured on the

loams and silt loams, though the sands and deep sandy loams produce the earliest berries.

Large quantities of barnyard and stable manure, with varying amounts of commercial fertilizers, are used in strawberry culture. Fertilizers high in potash seem to give the best results. Either the sulphate or muriate of potash give good results when used in conjunction with manure, as do also wood ashes. Applications of 200 pounds per acre of nitrate of soda are very effective in increasing the yield, though the shipping quality of the berries is seemingly impaired where this substance is used too freely. This, however, is not a serious matter here, owing to the nearness of markets.

Plants are set in April or May and given clean cultivation during the summer. Unfortunately the rush of other crops sometimes results in the neglect of the strawberry field. Young plants should not be allowed to bear fruit the first summer, but the blossoms are not always removed as they should be, owing to the work involved. Some trouble is experienced here by the plants rotting shortly after they are set out. This probably could be prevented by pruning back the roots one-third, setting shallow, and spreading the roots well when setting. The matted-row method of growing is the prevailing one here. The rows are about 4 feet apart, and the plants are placed from 18 to 24 inches apart.

A common mistake is made in allowing the plants to stand too long. If the fields are left more than two years, insects are likely to cause much trouble. Two years usually constitute the profitable life of a strawberry field. If left longer, the field should be closely mowed immediately after the berries are off and then burned over. It is a good practice to plow a furrow between the rows and fill with manure. By narrowing the beds down to 8 or 10 inches and leaving only an edge of the old row a field may be practically renewed. Mulching is not generally practised, although it would aid in keeping the fruit clean, especially on the heavier soils.

Several varieties are grown, among these the Bubach, Haverland, and Warfield (having imperfect blossoms), and the Sharpless and Clyde (with perfect blossoms) are favorite sorts.

The culture of dewberries is carried on in a limited way, and the industry is becoming more popular. Dewberries grow well on thin sandy soils and do not require heavy fertilizing, although liberal applications of stable manure and wood ashes are beneficial. They are propagated from tips like blackberries and raspberries and are set in rows about 5 feet apart with 3 or 4 feet between plants. These are tied to a stake driven into the ground near the plant. After fruiting the canes are removed to facilitate the growth of the young canes for the succeeding crop. The Lucretia is the most widely grown variety. Other good varieties are Manatee and Austins Improved.

Blackberries and raspberries are not grown extensively. They would be a profitable crop on some of the soils of this area. The blackberry for best results requires a rather heavy loamy soil, well supplied with organic matter. In this county wild blackberries are abundant, and perhaps for this reason their cultivation has not been taken up more generally. Some tested varieties are Snyder, Ancient Briton, Early Cluster, and Taylors Prolific.

# THE CLIMATE OF ANNE ARUNDEL COUNTY

BY

OLIVER L. FASSIG

## Introductory

Instrumental records of the weather at Annapolis are among the earliest in the history of the state, daily temperature changes having been recorded at old Fort Severn, the present site of the U. S. Naval Academy, in 1822, under the auspices of army surgeons. There were numerous interruptions in the record from 1822 to 1860, and a long gap from 1876 to 1894, but all told we have a record of daily temperatures at this locality of approximately 50 years. The daily rainfall record is fairly complete from 1857 to 1876, and complete from 1895 to date, a total period of about 40 years.

There is an excellent record for Jewell, in the southern portion of the county, covering a period of 20 years, from 1888 to 1908, with only slight interruptions. Records were maintained at several other localities within the limits of the county, but these were of short duration, none of them having been continued for more than a few months. The discussion of climatic conditions here presented is based entirely upon the records at Annapolis and at Jewell.

The available records containing the monthly and annual values, representing the weather history of Anne Arundel County for the greater portion of the past 85 years, have been summarized in the accompanying tables, while the history of the past 20 years is presented in much greater detail.

The average values of the weather elements and the daily and monthly variations are thus based upon observations covering a sufficiently long period to warrant their acceptance as true normal values for the areas represented. A detailed analysis of the tables seems unnecessary, in view of the fact that all of the important deductions concerning the climatic constants and variations are clearly indicated in the tables themselves,

and are more readily comprehended and more compactly presented in tabular form.

## THE TEMPERATURE

The topography of the county presents very little contrast, only a few points exceeding an elevation of 200 feet above sea-level; consequently the temperature variations are those due to latitude and the distribution of land and water. The influence of the Bay, while considerable along

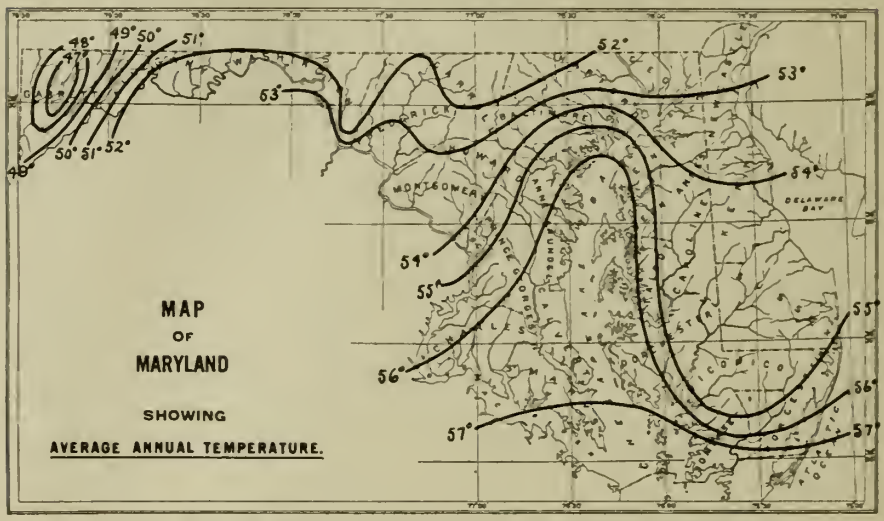


FIG. 1.—Map of Maryland showing average annual temperature.

the immediate shore-line, does not extend far inland in Anne Arundel County, particularly as the prevailing winds of the greater portion of the year are from the west. That the presence of the Bay has a decided influence, however, in the vicinity of the shores, is clearly seen by an examination of Fig. 3, showing the length of the period of safe plant growth throughout the states of Maryland and Delaware. The tempering influence of a large body of water is also revealed in Fig. 1, showing the distribution of the mean annual temperature in Maryland. The greater portion of the area comprising the Bay and the bordering counties lies between the annual isotherms of 56° and 57°, while to the north

and west of the Bay the isotherms are more numerous, showing a much greater variation in temperature within equal areas.

## THE PERIOD OF SAFE PLANT GROWTH

Anne Arundel County shares with the other Bay Shore counties the distinction of having a relatively long period of freedom from frosts. The period of safe plant growth will average fully 200 days—from the middle of April to the close of October. The protective influence of Chesapeake Bay is carried inland by means of the numerous broad rivers and bays.

The variations in the length of the period between the last occurrence of freezing weather in spring and the first in autumn are shown in Fig. 3, for Annapolis and vicinity from 1895 to 1915, and for the southern portion of the county, in the vicinity of Jewell, from 1893 to 1908.

The variations in the time of occurrence of the last spring freeze are considerable. Freezing weather has ceased at Annapolis as early as March 16, as in 1910, and as late as April 30, as in 1895 and in 1901. Approximately the same limits of variation are shown by the Jewell record. In the fall the first freezing weather has occurred as early as October 10 at Jewell, as in 1895, and October 11 at Annapolis, as in 1906. The date of the first fall freeze has several times been delayed beyond the 10th of November at Annapolis, and even occurred as late as December 1, as in 1896.

The total length of the period of safe plant growth has varied at Annapolis from 170 days, as in 1906, to 241 days as in 1896, with an average length for 21 years of 212 days. At Jewell the variation during 16 years of record has been from 183 days, as in 1898, to 224 days as in 1902, with an average length of 203 days. The details of the record for each year from 1893 to 1915 are shown in Table I and Fig. 2.

The average length of the period of safe plant growth, calculated for each county in Maryland and Delaware, is shown in Fig. 3. The considerable influence of the Bay is clearly brought out in the longer growing season of the Bay Shore counties as compared with inland counties.

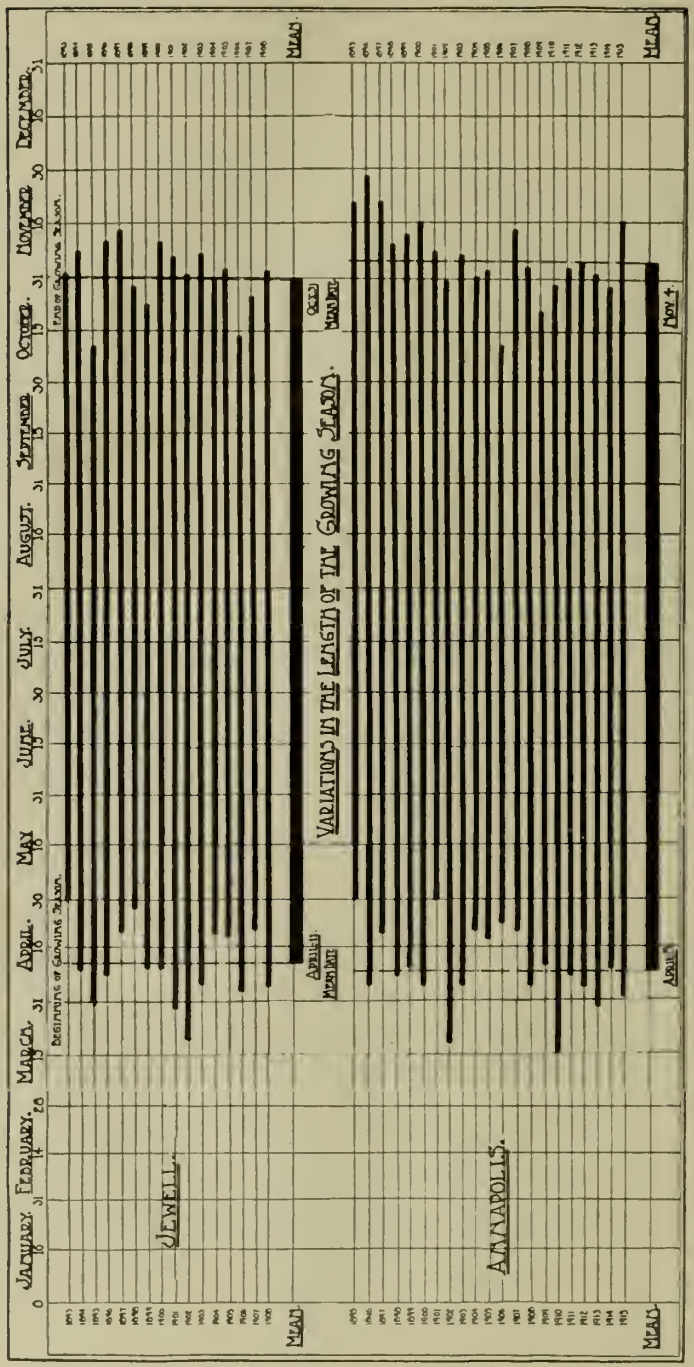


FIG. 2.—Diagram showing the variations in the length of growing season at Annapolis and Jewell.

TABLE I.

ANNAPOLIS, MARYLAND. LENGTH OF THE PERIOD OF SAFE PLANT GROWTH. JEWELL, MARYLAND

| Latest date with temperature 32° or lower in spring. | Earliest date with temperature 32° or lower in autumn. | Length of growing season last temperature 32° or lower to first temperature 32° or lower. | | Length of growing season last temperature 32° or lower to first temperature 32° or lower. | Latest date with temperature 32° or lower in spring. | Earliest date with temperature 32° or lower in autumn. |
|---|---|---|---|---|---|---|
| | | *Days.* | *Year.* | *Days.* | | |
| ..... | ..... | ..... | 1893 | (184) | (April 30) | (Oct. 31) |
| ..... | ..... | ..... | 1894 | (212) | (April 9) | Nov. 7 |
| (March 30) | Nov. 22 | (237) | 1895 | 194 | March 30 | Oct. 10 |
| April 4 | Dec. 1 | 241 | 1896 | 216 | April 8 | Nov. 10 |
| April 20 | Nov. 23 | 217 | 1897 | 206 | April 21 | Nov. 13 |
| April 7 | Nov. 2 | 209 | 1898 | 183 | April 28 | Oct. 28 |
| April 10 | Nov. 13 | 217 | 1899 | 195 | April 10 | Oct. 22 |
| April 5 | Nov. 16 | 225 | 1900 | 214 | April 10 | Nov. 10 |
| April 30 | Nov. 7 | 191 | 1901 | 222 | March 29 | Nov. 6 |
| March 19 | Oct. 30 | 225 | 1902 | 224 | March 20 | Oct. 30 |
| (April 5) | Nov. 7 | (216) | 1903 | 216 | April 5 | Nov. 7 |
| April 21 | Oct. 31 | 193 | 1904 | 194 | April 20 | Oct. 31 |
| April 19 | Nov. 2 | 197 | 1905 | 197 | April 19 | Nov. 2 |
| April 24 | Oct. 11 | 170 | 1906 | 192 | April 3 | Oct. 12 |
| April 21 | Nov. 14 | 207 | 1907 | 197 | April 21 | Oct. 25 |
| April 5 | Nov. 2 | 211 | 1908 | (212) | April 4 | (Nov. 2) |
| April 11 | Oct. 21 | 193 | 1909 | | | |
| March 16 | Oct. 30 | 228 | 1910 | | | |
| (April 8) | Nov. 3 | (209) | 1911 | | | |
| April 4 | Nov. 4 | 214 | 1912 | | | |
| March 29 | Nov. 1 | 217 | 1913 | | | |
| April 10 | Oct. 28 | 201 | 1914 | | | |
| April 1 | Nov. 16 | 229 | 1915 | | | |
| Means..April 8 | Nov. 6 | 212 | | 203 | April 11 | Oct. 31 |

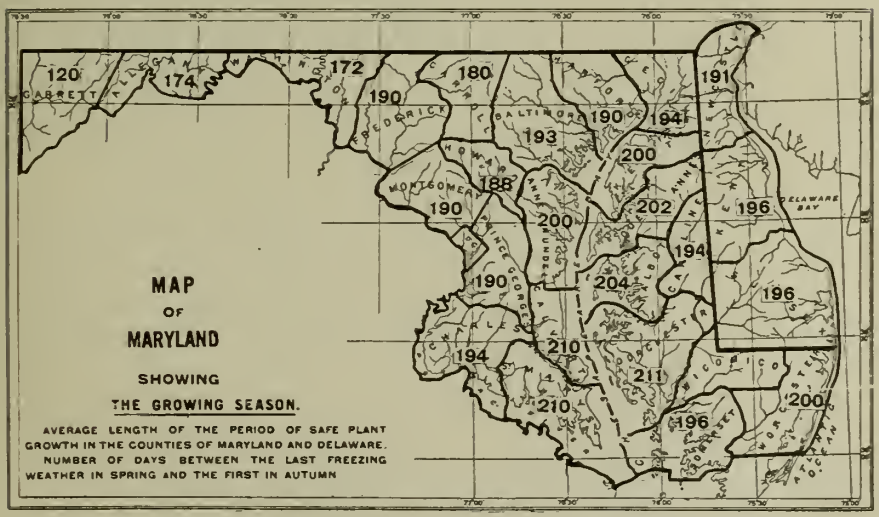


FIG. 3.—Map of Maryland showing the length of the growing season.

## THE PRECIPITATION

The accompanying chart, showing the total annual precipitation over Maryland and Delaware, emphasizes the fact that Anne Arundel County has a rainfall as great as that of any other county of Maryland, namely, about 45 inches. It is difficult to find a satisfactory explanation for the comparatively heavy precipitation over this particular area, although the amount is in harmony with the general increase in precipitation from southwest to northeast, across the state.

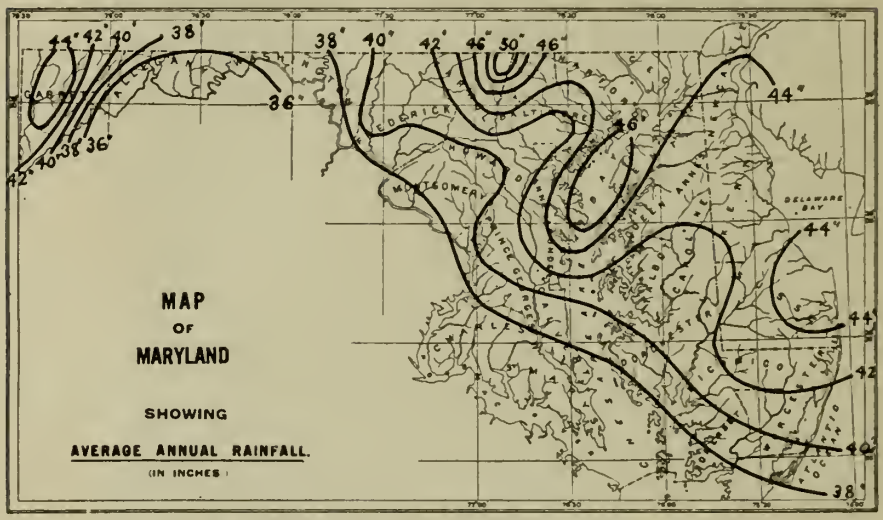


FIG. 4.—Map of Maryland showing average annual rainfall.

The distribution of precipitation through the year is remarkably uniform, when the average monthly values for the entire period of observations are considered, varying only between the limits of 3.12 inches in November to a maximum of 4.84 inches in August, at Annapolis, and between a minimum of 2.92 inches in November and a maximum of 6.01 inches in July, at Jewell.

In spite of this uniformity in monthly amounts recorded, the records reveal some very striking instances of wide departures from normal precipitation in individual storms. One of the most remarkable instances

of torrential rains recorded in the weather annals of this county occurred at Jewell, in July, 1897, a special account of which is given herewith.

Another instance of abnormal precipitation occurring within the limits of the county is also described in the accompanying account of an unprecedented fall of hail during the passage of a severe local storm across the state on June 22, 1915.

## FREQUENCY OF STATED AMOUNTS OF PRECIPITATION

A climatic factor of great importance, especially to the agricultural interests of the state, but one which is not often presented in local climatologies, is the frequency of stated amounts of rainfall. The crop value of a given amount of precipitation depends largely upon the manner in which it falls, whether in light or moderate amounts, which are easily taken up by the soil, or in short heavy showers resulting in the loss, so far as the soil is concerned, of a considerable percentage of the total amount recorded. All records of daily rainfalls at Annapolis and Jewell, during the past 20 years, have been classified as to amounts, and their average annual frequency determined, as shown in Table II.

TABLE II.
FREQUENCY OF DAYS WITH STATED PRECIPITATION.

| Amounts. (Inches.) | Average Annual Frequency. | | Average Annual Percentage. | |
|---|---|---|---|---|
| | Annapolis. | Jewell. | Annapolis. | Jewell. |
| 0.01″ to 0.10″ | 24 | 18 | 26 | 21 |
| 0.11″ to 0.25″ | 17 | 19 | 18 | 22 |
| 0.26″ to 0.50″ | 20 | 22 | 22 | 25 |
| 0.51″ to 0.75″ | 11 | 12 | 11 | 14 |
| 0.76″ to 1.00″ | 8 | 6 | 9 | 7 |
| Over 1.00 | 13 | 10 | 14 | 11 |
| 2.50″, or more. | 1 | 1 | 1 | 1 |

## DRY SPELLS

There is no general agreement as to what constitutes a "dry spell," and there is very little probability of reaching a satisfactory agreement without carefully defining the object in view in making the classification.

Recently one of the federal bureaus defined a critical period, or drought, as "a period of more than 20 days during the growing season between rainfalls of agricultural significance," and fixed upon a rainfall of 0.25 inch within a period of 24 consecutive hours as a rainfall of agricultural significance. The following lists (Tables III and IV) of dry spells at Annapolis and Jewell are based upon the definition quoted above.

TABLE III.

DRY SPELLS AT ANNAPOLIS, MARYLAND.

Periods of 20, or more days during which precipitation did not exceed 0.25 inch in any 24 consecutive hours, for the growing season, March 1 to September 30.

| Year. | | No. of days. | Year. | | No. of days. |
|---|---|---|---|---|---|
| 1894 | July 28 to August 20 | 24 | 1902 | July 1 to 23 | 23 |
| 1895 | No record | ..... | | August 12 to September 2 | 22 |
| 1896 | April 2 to 24 | 23 | 1903 | May 4 to 23 | 20 |
| | May 19 to June 7 | 20 | 1904 | August 23 to September 13 | 22 |
| 1897 | April 10 to 30 | 21 | 1905 | None | ..... |
| | June 5 to 24 | 20 | 1906 | April 16 to May 26 | 41 |
| | September 1 to 22 | 22 | | August 30 to September 26 | 28 |
| 1898 | March 3 to 23 | 21 | 1907 | None | ..... |
| | March 25 to April 27 | 34 | 1908 | June 17 to July 12 | 26 |
| | May 17 to June 12 | 27 | | September 7 to 27 | 21 |
| | June 14 to July 18 | 35 | 1909 | None | ..... |
| | August 20 to September 21 | 32 | 1910 | March 14 to April 3 | 21 |
| 1899 | April 17 to May 7 | 22 | 1911 | April 20 to May 30 | 41 |
| | May 19 to June 8 | 21 | 1912 | May 17 to June 5 | 20 |
| 1900 | April 22 to May 18 | 28 | 1913 | April 17 to May 14 | 28 |
| | June 25 to July 18 | 25 | 1914 | May 29 to June 21 | 24 |
| | July 31 to August 20 | 21 | | June 29 to July 27 | 29 |
| | August 25 to September 13 | 20 | 1915 | March 7 to April 2 | 27 |
| 1901 | None | ..... | | April 12 to May 3 | 22 |
| | | | | June 23 to July 28 | 36 |

TABLE IV.

DRY SPELLS AT JEWELL, MARYLAND.

Periods of 20 or more days during which precipitation did not exceed 0.25 inch in any 24 consecutive hours, for the growing season, March 1 to September 30.

| Year. | | No. of days. | Year. | | No. of days. |
|---|---|---|---|---|---|
| 1893 | March 18 to April 10 | 23 | 1900 | June 22 to July 11 | 20 |
| | June 7 to July 2 | 26 | | August 25 to September 13 | 20 |
| | No record remainder of season | ..... | 1901 | August 25 to September 14 | 21 |
| 1894 | No record | ..... | 1902 | July 10 to 29 | 20 |
| 1895 | September 7 to 30 | 24 | | August 7 to September 2 | 27 |
| 1896 | April 2 to 23 | 22 | 1903 | May 4 to 23 | 20 |
| | July 25 to August 23 | 30 | 1904 | August 11 to September 13 | 34 |
| | September 7 to 28 | 22 | 1905 | June 8 to 30 | 23 |
| 1897 | September 1 to 22 | 22 | 1906 | May 7 to 27 | 21 |
| 1898 | August 13 to September 14 | 33 | | June 27 to July 16 | 20 |
| 1899 | April 17 to May 7 | 21 | | August 30 to September 30 | 32 |
| | June 2 to 24 | 23 | 1907 | None | ..... |

## A REMARKABLE RAINFALL

The history of heavy rainfalls in the United States presents few instances of a heavier downpour than that recorded at Jewell, in Anne Arundel County, during the night of July 26 and the early morning of the 27th, 1897. Rain began about 6 p. m., of the 26th, in connection with a thunderstorm, and ended about noon of the following day, when a total fall of 14.75 inches was recorded by the cooperative observer of the U. S. Weather Bureau, Mr. Joseph Plummer. The bulk of this amount fell in less than 12 hours, while the heaviest rain occurred between 6 p. m. and 9 p. m. of the 26th. The accuracy of the record was well established by corroborative evidence presented during a personal investigation made by the writer soon after the occurrence of the storm.

This extraordinary rainfall was confined within narrow limits, but occurred during a period of unsettled weather of wide extent. Rains exceeding 3 inches in amount occurred throughout Maryland and Pennsylvania from the 26th to the 28th of July. The roads in the vicinity of Jewell were gullied in places to the depth of 4 and 5 feet by the rain. The lowlands were flooded, crops were destroyed, and fences carried away. The level of Lyons Creek, nearby, was higher than it had been at any time within the recollection of residents of the county.

Mr. E. G. Kinsell, cooperative observer of the Weather Bureau at Green Spring Furnace, in Washington County, Maryland, reports a similar occurrence of phenomenal rainfall in his vicinity on the 9th of August, 1887. Unfortunately, there was no standard raingage in use in that vicinity at the time, but rough measurements reported by different local observers indicate a rainfall from 12 to 14 inches. As the total duration of this rain-storm was but three hours and a half, from 6 p. m. to 9.30 p. m., it far exceeded in intensity the storm at Jewell.

## A PHENOMENAL FALL OF HAIL

A severe hail-storm passed over Maryland on the afternoon of June 22, 1915. It was first observed in Carroll County, at about 1.30 p. m., and moved in a southeast direction across Carroll, Baltimore, and Anne Arundel counties, crossed the Bay to Talbot County, and then over

Wicomico, Somerset, and Worcester counties, and out over the Atlantic Ocean. While the damage done to crops was not greater than on some previous occasions recorded in the local history of hail-storms, the size of the hailstones was phenomenal. The hail was particularly destructive to crops and exposed windows within a narrow belt probably less than 5 miles wide, extending from Union Bridge in Carroll County, through Sykesville, Woodstock, Ellicott City, Annapolis, Claiborne, and Oxford.

The storm seems to have attained its maximum intensity between 2.30 p. m. and 3 p. m., as it passed over the City of Annapolis.

The hailstones were of a size apparently never before seen in this vicinity. The large ones were generally referred to as being the size of a baseball or an orange. Numerous measurements of individual hail stones were reported. Among the most reliable known to the writer are those made at the United States Naval Academy in Annapolis. Ten or twelve stones accurately measured showed an average diameter of $3\frac{1}{2} \times 3$ inches, with a maximum major diameter of 3 15/16 inches. In another series the long diameter exceeded 4 inches. These measurements are equivalent to a circumference ranging from 10 to 12 inches. Reports from observers in other localities are in harmony with these figures.

All accounts of observers at Annapolis agree in that the ground was nowhere covered with hail, and that the larger stones were probably not more numerous than 8 or 10 to the square yard. Statements as to the weight of individual stones are less accurate. The information available is to the effect that "they averaged from 3 to 4 ounces"; that "they ran about 5 to the pound"; that "3 of them weighed a pound"; and that "some weighed 6 to 7 ounces, while stones of 4 to the pound were not uncommon."

It is rather remarkable that such a shower of stones lasting from 15 to 20 minutes, passing over a city with a population of approximately 10,000 people should have caused so little personal injury. The force of the impact of hailstones may be gaged quite accurately from the destruction wrought in the skylights of the Naval Academy buildings. The glass in these buildings was nearly half an inch in thickness, much of it with embedded wire netting. The cost of replacing the broken glass exceeded

HAILSTONES GATHERED AT THE U. S. NAVAL ACADEMY AFTER THE STORM OF JUNE 22, 1915.
THE BOTTOM OF THE TRAY IS 10.5 INCHES LONG.

$10,000. The accompanying photograph, Plate VIII, shows a tray filled with some of the larger hailstones gathered within the limits of the Academy grounds. To the right and left of the tray are shown fragments of the wire-glass $\frac{5}{16}$ of an inch thick shattered by the hail. The irregular, spiked outline of some of the stones is clearly indicated in the picture.

TABLE V.

MONTHLY MEAN TEMPERATURES AT ANNAPOLIS.

| Year. | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1822..... | 29.3 | 35.1 | 46.3 | 55.0 | 67.1 | 73.2 | 79.7 | 77.2 | 72.4 | 61.6 | 53.8 | 38.5 | 57.4 |
| 1831..... | 27.9 | 27.8 | 45.2 | 54.4 | 64 3 | 74.9 | 77.5 | 75.7 | 68.4 | 59.2 | 44.6 | **26.0** | 53.8 |
| 1832..... | 32.7 | 37.8 | 43.4 | 51.8 | 61.6 | 72.0 | 77.0 | 75.4 | 68.8 | 58.4 | 48.6 | **43.2** | 55.9 |
| 1833..... | 36.7 | 37.4 | 40.8 | 58.1 | 66.7 | 71.2 | 78.0 | 75.2 | 71.0 | 57.1 | 45.8 | 38.1 | 56.3 |
| 1834..... | 30.0 | 40.8 | 45.0 | 49.7 | 64.1 | 73.0 | 79.8 | 78.1 | **61.8** | 58.1 | 46.7 | 36.8 | 55.3 |
| 1843..... | 39.4 | 29.1 | ***32.5** | 51.5 | 60.4 | 72.1 | 75.7 | 75.1 | 70.4 | 53.2 | 42.0 | 36.8 | 53.2 |
| 1844..... | 30.4 | 32.8 | 43.0 | 56.2 | 69.0 | 72.0 | 78.0 | 75.4 | 69.1 | 55.9 | 46.3 | 37.5 | 55.5 |
| 1845..... | 39.3 | 36.5 | 46.6 | 55.6 | 62.5 | 73.4 | 77.7 | ..... | ..... | ..... | ..... | ..... | ..... |
| 1855..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 49.1 | 37.6 | ..... |
| 1856..... | 23.7 | 27.6 | 35.3 | 52.3 | 61.2 | 72.9 | 77.6 | †(*69.9*) | 65.2 | 53.8 | 44.0 | 32.0 | (*51.3*) |
| 1857..... ... | **23.2** | 39.6 | 38.3 | **44.8** | 62.1 | 71.2 | 75.6 | 74.9 | 68.8 | 55.9 | 44.7 | 42.2 | 53.4 |
| 1858..... | 40.7 | 31.4 | 40.4 | 53.4 | 60.4 | 76.2 | 79.3 | 75.5 | 67.6 | 59.3 | 42.7 | 39.5 | 55.5 |
| 1859..... | 35.3 | 38.5 | 48.3 | 51.0 | 63.9 | 71.1 | 76.4 | 75.0 | 68.3 | 53.0 | 47.7 | 35.0 | 55.3 |
| 1860..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1861..... | 33.4 | 39.3 | 43.6 | 52.9 | 60.6 | 74.1 | **74.4** | 75.3 | 70.4 | 61.0 | 46.0 | 38.6 | 55.8 |
| 1862..... | 33.8 | 35.6 | 41.0 | 49.8 | 63.2 | 70.6 | 76.3 | 77.7 | 70.8 | 60.8 | 46.3 | 38.1 | 55.3 |
| 1863..... | 38.1 | 36.4 | 41.8 | 52.4 | 65.0 | 71.0 | 77.7 | 79.4 | 66.4 | 56.3 | 48.4 | 37.4 | 55.9 |
| 1864..... | 34.9 | 36.3 | 40.2 | 50.7 | 68.4 | 72.8 | 77.8 | 79.0 | 67.4 | 55.1 | 46.2 | 38.4 | 55.6 |
| 1865..... | 30.0 | 34.2 | 47.4 | 56.8 | 65.0 | 77.3 | 78.0 | 75.3 | **74.6** | 56.0 | 46.5 | 39.0 | 56.7 |
| 1866..... | 32.0 | 34.7 | 41.5 | 55.8 | 62.3 | 74.6 | 79.7 | 72.8 | 70.9 | 58.4 | 47.9 | 36.8 | 55.6 |
| 1867..... | 30.8 | **42.5** | 41.0 | 55.5 | 59.9 | 72.4 | 77.7 | 75.9 | 70.5 | 57.7 | 48.8 | 36.9 | 55.8 |
| 1868..... | 34.4 | 32.0 | 44.1 | 50.2 | 61.4 | 73.0 | 82.0 | 77.5 | 68.3 | 56.4 | 48.8 | 36.5 | 55.4 |
| 1869..... | 41.3 | 41.6 | 43.1 | 55.6 | 62.3 | 76.8 | 78.5 | 76.9 | 69.5 | 53.1 | 43.4 | 41.3 | 57.0 |
| 1870..... | 43.1 | 37.8 | 40.9 | 54.0 | 65.0 | 76.5 | 81.1 | 78.7 | 71.3 | 60.9 | 49.4 | 38.6 | 58.1 |
| 1871..... | 35.4 | 39.1 | 49.3 | **61.3** | 65.8 | 75.6 | 76.4 | 79.8 | 65.3 | 59.2 | 47.4 | 36.7 | 57.6 |
| 1872..... | 38.7 | 37.9 | 37.5 | 55.7 | 66.4 | 75.9 | **83.7** | 82.1 | 73.4 | 59.8 | 44.8 | 35.0 | 57.6 |
| 1873..... | 32.8 | 35.4 | 41.6 | 52.8 | 63.9 | **78.3** | (*80.4*) | **83.5** | 69.7 | 58.5 | 43.5 | 41.8 | (*56.8*) |
| 1874..... | ..... | ..... | ..... | ..... | 64.9 | 76.5 | 77.4 | 74.6 | 69.3 | 56.2 | 44.6 | 38.1 | ..... |
| 1875..... | 29.0 | 28.6 | 39.0 | 47.5 | 63.2 | 72.6 | 77.1 | 73.0 | 67.8 | 55.4 | 42.0 | 37.4 | 52.7 |
| 1876..... | 41.1 | 36.8 | 39.5 | 50.2 | 62.6 | 73.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1894..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 73.6 | 70.2 | ..... | 43.8 | ..... | ..... |
| 1895..... | 29.6 | 26.6 | ..... | 53.6 | 61.6 | ..... | ..... | ..... | 73.0 | 54.4 | 46.2 | 37.4 | ..... |
| 1896..... | 31.4 | 34.8 | 38.5 | 57.8 | 70.5 | 76.1 | (*78.0*) | 76.4 | 68.4 | 58.2 | **54.0** | 40.1 | (*57.0*) |
| 1897..... | (*50.0*) | (*36.0*) | 47.0 | 54.9 | 64.1 | 72.5 | 76.8 | 76.1 | 69.8 | 60.9 | 50.8 | 41.0 | (*56.7*) |
| 1898..... | 38.4 | 36.4 | **50.3** | 52.8 | 67.2 | 76.8 | 78.6 | 80.3 | 71.2 | 58.6 | 43.8 | (*34.0*) | (*57.4*) |
| 1899..... | 34.8 | 28.4 | 44.4 | 55.0 | 65.8 | 76.6 | 77.8 | 76.3 | 67.8 | 59.4 | 48.0 | 38.2 | 56.0 |
| 1900..... | 35.8 | 34.0 | 39.6 | 55.4 | 65.6 | 74.0 | 79.8 | 80.9 | 74.5 | 62.6 | 49.6 | 36.4 | 57.3 |
| 1901. ..... | 35.4 | 30.6 | 43.8 | 50.4 | 64.1 | 74.5 | 83.0 | 78.4 | 70.6 | 58.9 | 42.8 | 35.0 | 55.6 |
| 1902..... | 32.5 | 30.5 | 47.8 | 54.2 | ..... | ..... | ..... | ..... | ..... | 59.2 | 52.9 | 36.0 | ..... |
| 1903..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 56.8 | 45.0 | 33.2 | ..... |
| 1904..... | 29.0 | 29.2 | 41.8 | 49.3 | 66.3 | 72.6 | 76.6 | 75.6 | 69.4 | 55.4 | 43.0 | 30.0 | 53.2 |
| 1905..... | (*30.0*) | **26.0** | 45.7 | 53.4 | 66.2 | 73.1 | 75.9 | 76.4 | 68.8 | 60.5 | 46.6 | 39.4 | (*55.2*) |
| 1906..... | 40.0 | (*35.0*) | 39.2 | 57.0 | 66.1 | 74.6 | 76.6 | 78.0 | 73.6 | 58.4 | 48.1 | 36.6 | (*56.9*) |
| 1907..... | 36.2 | 29.5 | 46.4 | 47.0 | **58.0** | **66.8** | 76.2 | 73.4 | 70.0 | **52.8** | 45.5 | 37.6 | 53.3 |
| 1908... ..... | 34.4 | 29.4 | 44.6 | 54.4 | 64.4 | 72.2 | 78.2 | 73.6 | 67.8 | 59.2 | 46.0 | 37.8 | 55.2 |
| 1909..... | 35.3 | 41.0 | 41.4 | 54.0 | 62.8 | 73.5 | 75.1 | 74.4 | 68.6 | 54.0 | 50.9 | 32.5 | 55.3 |
| 1910..... | 32.9 | 33.7 | 48.4 | 56.2 | 59.8 | 68.8 | 77.0 | 72.2 | 70.4 | 59.6 | **41.2** | 29.0 | 54.1 |
| 1911..... | 36.6 | 35.2 | (*41.0*) | (*52.5*) | **71.6** | 74.8 | 80.9 | 78.9 | 73.2 | 60.2 | 47.0 | 41.7 | (*57.8*) |
| 1912..... | 26.4 | 31.4 | 41.3 | 55.6 | 66.3 | 73.2 | 77.7 | 75.8 | 73.4 | 61.5 | 50.1 | 41.2 | 56.2 |
| 1913..... | **43.9** | 36.2 | 48.2 | 56.0 | 66.0 | 73.7 | 79.3 | 77.4 | 71.4 | 61.4 | 50.0 | 43.0 | **58.9** |
| 1914..... | 38.0 | 32.8 | 41.0 | 54.0 | 68.4 | 75.6 | 77.8 | 77.8 | 68.4 | **63.1** | 48.6 | 35.4 | 56.7 |
| 1915..... | 36.4 | 38.7 | 39.8 | 58.8 | 64.4 | 71.6 | 77.4 | 75.6 | 72.6 | 60.0 | 47.9 | 35.9 | 56.6 |
| No. of years.. | 47 | 47 | 46 | 47 | 47 | 46 | 45 | 45 | 46 | 47 | 49 | 48 | ..... |
| Means..... | 34.1 | 34.4 | 42.8 | 53.6 | 64.3 | 73.6 | 78.1 | 76.4 | 69.8 | 58.0 | 46.8 | 37.2 | 55.8 |

* Figures in bold face are highest and lowest. † Figures in parenthesis are interpolated.

TABLE VI.

MONTHLY MEAN TEMPERATURES AT JEWELL.

| Year. | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1888..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **52.4** | 47.9 | 35.9 | ..... |
| 1889..... | 38.2 | 30.0 | 42.4 | 55.0 | 66.6 | 72.8 | 76.8 | 72.9 | 66.7 | 53.6 | 47.6 | **45.7** | 55.7 |
| 1890..... | ***44.4** | **43.6** | 41.2 | 54.9 | 65.4 | 76.4 | 77.0 | 75.2 | 69.8 | 57.1 | 48.6 | 35.2 | **57.4** |
| 1891..... | 38.2 | †(*43.0*) | (*39.0*) | **57.2** | 63.6 | 74.8 | 74.7 | 76.1 | 71.8 | 54.6 | 44.0 | 42.4 | (*56.6*) |
| 1892..... | 28.4 | 32.8 | **35.8** | (*51.5*) | 63.7 | **76.7** | 76.0 | 77.2 | 67.8 | 53.2 | **40.8** | 31.4 | (*52.9*) |
| 1893..... | **24.6** | 36.2 | 42.4 | 56.0 | 63.8 | 74.3 | 78.0 | ..... | ..... | ..... | ..... | ..... | ..... |
| 1894..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 45.1 | 38.8 | ..... |
| 1895..... | 33.4 | **25.8** | 42.8 | 53.6 | 62.0 | 74.1 | **71.6** | 76.3 | 72.5 | 52.9 | 47.6 | 39.8 | 54.4 |
| 1896..... | 33.2 | 37.1 | 38.7 | 57.0 | **68.3** | 71.2 | 76.4 | 75.8 | 67.8 | 54.3 | **52.6** | 35.6 | 55.7 |
| 1897..... | 31.2 | 36.2 | 46.6 | 53.1 | 60.1 | 68.9 | 75.6 | ..... | ..... | ..... | ..... | 38.8 | ..... |
| 1898..... | 37.0 | 35.0 | 43.0 | 50.8 | 62.5 | 71.1 | 76.7 | 75.8 | 70.0 | 57.8 | 43.7 | 35.0 | 55.4 |
| 1899..... | 32.2 | 27.0 | 41.7 | 53.4 | 63.4 | 73.7 | 75.5 | 73.9 | **66.4** | 58.0 | 42.2 | 37.8 | 53.8 |
| 1900..... | 36.2 | 34.5 | 38.0 | 54.2 | 64.0 | 72.3 | 76.6 | **78.7** | **73.0** | **62.0** | 52.0 | 37.6 | 56.6 |
| 1901..... | 35.5 | 30.0 | 45.0 | 49.8 | 61.9 | 71.6 | **79.2** | 75.5 | 67.4 | 56.2 | 41.3 | 35.2 | 54.0 |
| 1902..... | 32.4 | 29.1 | 46.4 | 53.2 | 64.1 | 71.9 | 76.3 | 72.5 | 66.8 | 59.4 | **52.6** | 36.3 | 55.1 |
| 1903..... | 33.8 | 38.8 | **50.6** | 54.1 | 64.5 | 67.0 | 75.8 | 72.0 | 67.4 | 57.8 | 42.6 | 32.5 | 54.7 |
| 1904..... | 28.2 | 28.5 | 42.2 | 50.2 | 64.8 | 71.5 | 71.8 | 72.6 | 68.6 | 54.9 | 44.2 | **31.2** | **52.4** |
| 1905..... | 30.3 | **25.8** | 45.4 | 54.0 | 65.8 | 71.6 | 75.6 | 73.6 | 68.4 | 58.8 | 45.6 | 38.3 | 54.4 |
| 1906..... | 40.4 | 35.4 | 38.1 | 55.5 | 62.0 | 72.0 | (*75.0*) | 76.3 | 71.5 | 56.1 | 47.0 | 37.4 | (*55.6*) |
| 1907..... | 37.0 | 29.3 | 47.6 | (*48.0*) | **57.1** | **65.1** | 75.1 | **71.9** | 69.2 | 53.0 | 45.4 | 39.1 | (*53.2*) |
| 1908..... | 35.0 | 31.3 | 48.0 | 55.8 | 64.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| No. of years.. | 19 | 19 | 19 | 19 | 19 | 18 | 18 | 16 | 16 | 17 | 18 | 19 | ..... |
| Means..... | 34.2 | 33.1 | 43.2 | 53.5 | 63.6 | 72.1 | 75.8 | 74.8 | 69.1 | 56.0 | 46.2 | 37.1 | 54.9 |

* Figures in bold face are highest and lowest. † Figures in parenthesis are interpolated.

TABLE VII.

MONTHLY AND ANNUAL PRECIPITATION AT ANNAPOLIS, MARYLAND, ANNE ARUNDEL COUNTY.
Elevation, 20 feet; lat. 38°, 59′; long. 76°, 30′.

| Year. | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1843 | ..... | ..... | 3.00 | 2.59 | 5.71 | 1.24 | 6.28 | 5.99 | 10.37 | 2.64 | 4.96 | 4.26 | ..... |
| 1844 | 4.22 | 0.94 | 3.55 | 1.08 | 4.69 | 3.91 | 2.96 | 1.67 | 6.47 | 4.28 | 3.62 | 3.37 | 40.76 |
| 1845 | 3.69 | 5.10 | 2.85 | 2.25 | 3.24 | 6.94 | 3.18 | ..... | ..... | ..... | .... | ..... | ..... |
| 1857 | 2.97 | 0.77 | 1.67 | 3.68 | 6.32 | **8.89** | 6.19 | 7.98 | 1.53 | 3.43 | 1.77 | 6.44 | 51.64 |
| 1858 | 1.79 | 1.69 | **0.70** | 4.43 | 6.75 | 1.95 | 1.80 | 3.17 | 2.31 | 3.36 | 5.03 | 5.61 | 38.59 |
| 1859 | 5.16 | 3.79 | 5.72 | 6.12 | 4.06 | 5.76 | 1.15 | 3.63 | 7.40 | 3.07 | 2.10 | 3.49 | 51.45 |
| 1860 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | .... | ..... | ..... |
| 1861 | 4.29 | 1.87 | 3.86 | 5.73 | 5.39 | 4.13 | 5.97 | 9.13 | 4.50 | 2.89 | 4.59 | 1.71 | 54.06 |
| 1862 | 5.17 | 5.01 | 4.41 | 6.03 | 2.82 | 7.11 | 7.33 | 2.20 | 3.84 | 2.77 | 4.65 | 1.39 | 52.73 |
| 1863 | 4.68 | 5.17 | ..... | ..... | 3.55 | 2.65 | 5.11 | 2.03 | 2.78 | 2.95 | 2.09 | 4.29 | ..... |
| 1864 | 2.01 | **0.54** | 7.24 | 7.18 | 3.38 | 1.74 | 2.06 | 2.77 | 3.65 | 3.20 | 3.66 | 4.83 | 42.26 |
| 1865 | 4.68 | 5.14 | 6.58 | 2.98 | 6.34 | 2.18 | 8.75 | 3.86 | 3.79 | 4.16 | 3.66 | 5.47 | 57.59 |
| 1866 | 2.19 | 5.43 | 1.16 | 3.04 | 4.33 | 8.11 | 6.06 | 3.51 | 10.63 | **8.41** | 3.72 | 3.94 | 60.53 |
| 1867 | *1.32 | 5.44 | **10.25** | 2.16 | 6.64 | 6.41 | 4.44 | **14.55** | 1.91 | 5.52 | 2.37 | 2.98 | 63.99 |
| 1868 | 4.17 | 2.39 | 3.41 | 3.74 | **8.14** | 3.37 | 2.28 | 8.39 | 6.34 | 1.57 | 5.49 | 3.08 | 52.37 |
| 1869 | 4.70 | 5.45 | 4.36 | 2.80 | 5.57 | 2.89 | 5.60 | 1.60 | 4.04 | 7.19 | 3.51 | 6.15 | 53.86 |
| 1870 | 3.23 | 4.52 | 3.17 | 5.17 | 5.33 | 4.38 | 5.41 | 1.77 | 2.96 | 3.50 | 1.82 | 1.33 | 42.59 |
| 1871 | 3.19 | 3.83 | 6.59 | 1.87 | 4.62 | 5.20 | 7.91 | 1.06 | 2.37 | 3.69 | 4.27 | 2.46 | 47.06 |
| 1872 | 1.41 | 1.57 | 4.36 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | .... | ..... | ..... |
| 1873 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 3.85 | 3.62 | 0.85 | ..... |
| 1874 | ..... | ..... | ..... | ..... | 3.67 | 2.68 | 4.05 | 2.22 | 5.07 | **0.09** | 2.10 | 3.65 | ..... |
| 1875 | 3.39 | 3.78 | 4.01 | 4.56 | **1.19** | 4.34 | 2.43 | 10.50 | 2.52 | 1.56 | 4.31 | 2.97 | 45.56 |
| 1876 | 1.40 | 2.87 | 5.30 | 2.80 | 4.95 | 2.87 | ..... | ..... | ..... | ..... | .... | ..... | ..... |
| 1894 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.93 | 1.53 | ..... | 2.16 | ..... | ..... |
| 1895 | †(*4.00*) | (*1.10*) | (*3.00*) | 6.63 | 3.41 | (*4.00*) | (3.50) | (1.50) | (1.25) | **(2.50)** | 1.87 | 2.74 | (*35.50*) |
| 1896 | 2.70 | **7.48** | 4.53 | 1.25 | 2.25 | 3.11 | (*3.75*) | (*0.91*) | (*3.71*) | (*0.38*) | 2.41 | **0.77** | (*33.25*) |
| 1897 | (*2.19*) | 4.68 | 2.46 | 2.80 | 6.67 | 1.73 | 5.76 | 4.39 | 2.17 | 3.69 | 4.98 | 3.48 | (*45.00*) |
| 1898 | 2.37 | 1.40 | 1.44 | 1.11 | 3.28 | **0.88** | 3.17 | 2.81 | 1.35 | 8.13 | 4.69 | (*4.35*) | (*34.98*) |
| 1899 | 3.83 | 4.97 | 5.49 | 0.98 | 3.60 | 2.05 | 4.66 | (*5.97*) | 4.25 | 4.50 | 2.80 | 1.60 | (*44.70*) |
| 1900 | 3.00 | 6.00 | 4.05 | 3.40 | 1.60 | 6.41 | 2.00 | 1.07 | 6.16 | 2.35 | 2.40 | 3.00 | 41.44 |
| 1901 | 3.30 | 1.50 | 3.76 | 7.48 | 4.27 | 1.85 | 6.80 | 10.40 | 4.50 | 1.20 | 2.41 | 6.15 | 53.62 |
| 1902 | 3.55 | 5.75 | 3.95 | 3.60 | 2.42 | 7.00 | 2.10 | 1.45 | 6.70 | 6.90 | 5.40 | **7.80** | 56.62 |
| 1903 | 4.15 | 6.20 | 5.60 | 4.00 | 3.50 | 4.95 | 8.00 | 6.67 | 1.05 | 5.40 | 1.12 | 3.40 | 54.04 |
| 1904 | 3.70 | 2.20 | 3.79 | 2.40 | 2.95 | 6.67 | 5.98 | 7.40 | 6.22 | 3.30 | 2.15 | 3.50 | 50.26 |
| 1905 | 4.59 | 1.98 | 3.08 | 4.30 | 3.58 | 7.61 | **9.99** | 4.13 | 2.31 | 2.60 | 1.06 | 5.60 | 50.83 |
| 1906 | 3.24 | 2.87 | 5.78 | 2.81 | 1.75 | 8.17 | 6.29 | 8.87 | 1.18 | 3.92 | 2.95 | 3.80 | 51.63 |
| 1907 | 3.85 | 3.55 | 3.45 | 4.12 | 8.02 | 7.85 | 5.09 | 5.01 | **10.95** | 3.43 | **6.19** | 5.08 | **66.59** |
| 1908 | 4.25 | 5.39 | 4.15 | 3.36 | 4 97 | 2.05 | 9.53 | 5.96 | 3.38 | 3.95 | 1.01 | 4.50 | 52.50 |
| 1909 | 2.97 | 5.40 | 5.82 | 2.94 | 5.23 | 7.07 | 1.65 | 3.80 | 5.50 | 1.85 | 2.70 | 5.40 | 50.33 |
| 1910 | **5.41** | 1.81 | 2.28 | **9.36** | 6.39 | 8.05 | 2.67 | 2.03 | 2.54 | 3.72 | 4.72 | 3.47 | 52.45 |
| 1911 | 3.44 | 3.09 | (*2.50*) | 1.69 | 1.51 | 2.48 | **1.03** | 14.05 | **0.92** | 2.30 | 2.61 | 1.76 | 37.38 |
| 1912 | 3.06 | 2.35 | 6.62 | 2.45 | 4.28 | 3.45 | 4.59 | 1.02 | 6.45 | 1.86 | 1.67 | 4.58 | 42.38 |
| 1913 | 2.30 | 1.20 | 5.27 | 5.19 | 3.87 | 2.48 | 2.12 | 3.25 | 3.22 | 3.61 | 1.70 | 2.00 | 36.21 |
| 1914 | 5.20 | 2.58 | 2.42 | 3.50 | 1.69 | 2.52 | 1.69 | 9.31 | 2.47 | 1.83 | 2.61 | 4.42 | 40.24 |
| 1915 | 4.82 | 5.74 | 1.05 | **0.90** | 4.17 | 5.82 | 1.29 | 6.85 | 1.48 | 4.68 | **0.85** | 3.61 | 41.26 |
| No. of years.. | 40 | 40 | 40 | 39 | 41 | 40 | 41 | 40 | 40 | 40 | 41 | 40 | ..... |
| Means..... | 3.49 | 3.56 | 4.07 | 3.65 | 4.30 | 4.46 | 4.41 | 4.84 | 4.04 | 3.51 | 3.12 | 3.73 | 47.18 |

* Figures in bold face are highest and lowest. † Figures in parenthesis are interpolated.

TABLE VIII.

MONTHLY AND ANNUAL PRECIPITATION AT JEWELL, ANNE ARUNDEL COUNTY, MARYLAND.
Elevation 165 feet. Lat. 38°, 45′; long. 76°, 37′.

| Year. | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1888..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **9.15** | 5.57 | 5.85 | 2.15 | ..... |
| 1889..... | 2.73 | 2.95 | 5.47 | *12.20 | 7.28 | 5.10 | 10.25 | 1.67 | 5.25 | 6.25 | 6.55 | T | 65.70 |
| 1890..... | 1.52 | 5.55 | 3.45 | 2.00 | 4.84 | 1.84 | 3.17 | 4.45 | 5.88 | 4.91 | 0.75 | 5.65 | 44.01 |
| 1891..... | 3.63 | *(5.00) | (8.30) | 2.00 | 5.50 | 5.40 | 12.15 | 6.88 | 0.88 | 4.00 | 2.71 | 2.77 | 59.22 |
| 1892..... | 4.33 | 3.15 | 8.35 | ..... | 4.75 | 5.68 | 4.62 | 2.47 | 3.08 | .50 | 5.17 | 2.25 | ..... |
| 1893..... | 2.05 | 2.22 | 2.80 | 2.56 | 4.52 | 1.04 | 2.50 | ..... | ..... | ..... | ..... | ..... | ..... |
| 1894..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 3.20 | 1.44 | 2.80 | ..... |
| 1895..... | 5.09 | 1.17 | 3.26 | 6.25 | 4.31 | 4.60 | 3.23 | 1.51 | 0.93 | 2.35 | 1.64 | 2.45 | 36.79 |
| 1896..... | 1.33 | 5.60 | 4.31 | 1.18 | 4.86 | 4.75 | 3.75 | 0.91 | 3.71 | 0.38 | 2.11 | 0.30 | 33.19 |
| 1897..... | 2.19 | 5.25 | 3.00 | 2.16 | 5.79 | 2.29 | 19.90 | 4.71 | 1.37 | 5.79 | 2.91 | 3.32 | 58.68 |
| 1898..... | 2.47 | 1.55 | 3.79 | 3.51 | 4.23 | 2.57 | 3.57 | 4.17 | 2.98 | 3.93 | 3.57 | 4.35 | 40.69 |
| 1899..... | 3.02 | 3.94 | 4.46 | 1.27 | 2.45 | 2.71 | 5.79 | 5.97 | 4.81 | 5.07 | 1.41 | 1.62 | 42.52 |
| 1900..... | 2.42 | 5.60 | 2.77 | 2.74 | 2.01 | 5.47 | 3.81 | 3.82 | 5.88 | 2.53 | 1.94 | 3.06 | 42.05 |
| 1901..... | 3.04 | 0.65 | 3.52 | 6.80 | 2.35 | 4.17 | 5.53 | 5.08 | 2.72 | 1.34 | 3.17 | 5.52 | 43.89 |
| 1902..... | 3.05 | 5.05 | 2.56 | 2.37 | 2.29 | 7.68 | 4.28 | .87 | 5.51 | 7.12 | 3.55 | 5.59 | 49.92 |
| 1903..... | 3.53 | 4.46 | 6.20 | 4.41 | 2.34 | 5.91 | 4.35 | 5.12 | 0.96 | 3.90 | 0.98 | 2.48 | 44.64 |
| 1904..... | 1.98 | 1.84 | 3.02 | 2.62 | 1.88 | 4.19 | 7.02 | .69 | 5.44 | 3.11 | 2.16 | 3.89 | 37.84 |
| 1905..... | 4.03 | 3.06 | 2.94 | 3.87 | 3.01 | 2.71 | 7.82 | 5.40 | 3.46 | 1.61 | 0.45 | 5.04 | 43.40 |
| 1906..... | 2.62 | 2.71 | 5.58 | 2.11 | 1.82 | 8.36 | 4.27 | 7.53 | 0.71 | 5.00 | 2.44 | 3.21 | 46.36 |
| 1907..... | 3.07 | 2.27 | 2.23 | 3.39 | 5.42 | 6.73 | 2.20 | 4.50 | 5.78 | 2.99 | 6.60 | 4.26 | 49.44 |
| 1908..... | 3.94 | 2.77 | 1.36 | 2.02 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| No. of years.. | 19 | 19 | 19 | 18 | 18 | 18 | 18 | 17 | 18 | 19 | 19 | 19 | ..... |
| Means..... | 2.95 | 3.41 | 4.07 | 3.53 | 3.87 | 4.51 | ‡6.01 | 3.87 | 3.81 | 3.66 | 2.92 | 3.20 | 45.81 |

* Figures in bold face are highest and lowest. † Figures in parenthesis are interpolated.
‡ This amount includes the phenomenal rainfall of 14.75 inches in 24 hours recorded on July 26-27, 1897.

TABLE IX.

RÉSUMÉ OF MONTHLY AND ANNUAL CLIMATIC DATA (1894-1915) AT ANNAPOLIS, MARYLAND.

(Temperatures in degrees Fahrenheit; precipitation in inches.)

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean monthly and annual temperature (45 years.) | 34.1 | 34.4 | 42.8 | 53.6 | 64.3 | 73.6 | 78.1 | 76.6 | 69.8 | 58.0 | 46.8 | 37.2 | 55.8 |
| Monthly maximum temperature. | 74.0 | 68.0 | 78.0 | 90.0 | 95.0 | 99.0 | 105.0 | 100.0 | 98.0 | 89.0 | 85.0 | 71.0 | 105.0 |
| Monthly minimum temperature. | —3.0 | —6.0 | 11.0 | 24.0 | 35.0 | 46.0 | 54.0 | 52.0 | 40.0 | 29.0 | 17.0 | 8.0 | —6.0 |
| Mean daily maximum temperature. | 42.0 | 40.0 | 51.9 | 63.0 | 74.2 | 81.4 | 86.3 | 83.9 | 78.0 | 66.9 | 55.3 | 43.6 | 63.9 |
| Mean daily minimum temperature. | 27.7 | 25.2 | 36.0 | 45.3 | 56.4 | 65.1 | 69.7 | 68.7 | 62.9 | 50.7 | 39.5 | 30.1 | 48.1 |
| Mean daily range in temperature. | 14.1 | 14.6 | 15.5 | 17.8 | 17.7 | 16.6 | 16.5 | 15.4 | 15.4 | 16.2 | 15.8 | 13.5 | 15.8 |
| Greatest daily range in temperature. | 47.0 | 40.0 | 39.0 | 47.0 | 37.0 | 38.0 | 35.0 | 33.0 | 35.0 | 41.0 | 40.0 | 35.0 | 47.0 |
| Number of days with temperature 90° or above. | 0.0 | 0.0 | 0.0 | .1 | 1.2 | 4.4 | 9.6 | 6.1 | 2.0 | 0.0 | 0.0 | 0.0 | 23.4 |
| Number of days with temperature 32° or below. | 22.0 | 21.2 | 11.0 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .4 | 5.9 | 19.3 | 81.7 |
| Number of days with temperature 14° or below. | 2.2 | 4.0 | .2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 7.4 |
| Number of days with mean temperature of 42° or above, between last 32° or below in spring and first 32° or below in autumn. | ..... | ..... | 1 | 19 | 31 | 30 | 31 | 31 | 30 | 27 | 5 | ..... | 205 |
| Mean monthly and annual precipitation (40 years). | 3.49 | 3.56 | 4.07 | 3.65 | 4.30 | 4.46 | 4.41 | 4.84 | 4.04 | 3.51 | 3.12 | 3.73 | 47.18 |
| Maximum precipitation in 24 hours. | 2.43 | 2.87 | 2.10 | 2.80 | 2.00 | 2.23 | 3.00 | 7.35 | 5.80 | 3.50 | 2.40 | 2.90 | 7.35 |
| Mean monthly and annual snowfall. | 6.4 | 8.8 | 5.1 | .4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T. | .7 | 3.6 | 25.0 |
| Average daily amount of precipitation on days with .01 inch or more. | .49 | .49 | .43 | .43 | .46 | .51 | .47 | .58 | .65 | .60 | .47 | .55 | .51 |
| Average number of days with precipitation of .01 inch or more. | 8.0 | 8.0 | 9.0 | 8.0 | 9.0 | 9.0 | 9.0 | 9.0 | 6.0 | 7.0 | 7.0 | 7.0 | 96.0 |
| Average number of days with snowfall of .10 inch or more. | 2.8 | 2.7 | 1.8 | .2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .4 | 1.2 | 9.1 |
| Average number of clear days. | 13.0 | 13.0 | 13.0 | 14.0 | 15.0 | 14.0 | 15.0 | 16.0 | 18.0 | 17.0 | 15.0 | 15.0 | 178.0 |
| Average number of partly cloudy days. | 5.0 | 4.0 | 5.0 | 6.0 | 7.0 | 6.0 | 8.0 | 6.0 | 5.0 | 6.0 | 5.0 | 4.0 | 67.0 |
| Average number of cloudy days. | 13.0 | 11.0 | 13.0 | 10.0 | 9.0 | 10.0 | 8.0 | 9.0 | 7.0 | 8.0 | 10.0 | 12.0 | 120.0 |
| Average number of days with hail. | .05 | 0.0 | 0.0 | .1 | .3 | .1 | .2 | .1 | 0.0 | .05 | 0.0 | 0.0 | .9 |
| Average number of days with sleet. | .5 | .8 | .6 | .1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .1 | .5 | 2.6 |
| Average number of days with thunderstorms. | .2 | .2 | .3 | .4 | .8 | 1.2 | 1.6 | .9 | .6 | .3 | .2 | .05 | 7.2 |
| Prevailing wind direction..... | NW | NW | NW | NW | SE | SE | SW | SE | SE | NE | NW | NW | NW |
| Average date of last and first snowfall of .10 inch or more. | | | Last March 11th. | | | | | | | First November 20th. | | | |

TABLE X.

RÉSUMÉ OF MONTHLY AND ANNUAL CLIMATIC DATA (1888-1908) AT JEWELL, MARYLAND.

(Temperatures in degrees Fahrenheit ; precipitation in inches.)

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean monthly and annual temperature. | 34.2 | 33.1 | 43.2 | 53.5 | 63.6 | 72.1 | 75.8 | 74.8 | 69.1 | 56.0 | 46.2 | 37.1 | 54.9 |
| Monthly maximum temperature. | 74.0 | 72.0 | 88.0 | 94.0 | 95.0 | 99.0 | 100.0 | 100.0 | 96.0 | 88.0 | 78.0 | 68.0 | 100.0 |
| Monthly minimum temperature. | 1.0 | -14.0 | 10.0 | 21.0 | 37.0 | 45.0 | 53.0 | 50.0 | 38.0 | 28.0 | 16.0 | 1.0 | -14.0 |
| Mean daily maximum temperature. | 42.1 | 40.1 | 53.6 | 63.5 | 73.0 | 79.7 | 84.1 | 82.7 | 77.9 | 66.7 | 55.3 | 44.7 | 63.1 |
| Mean daily minimum temperature. | 25.9 | 23.3 | 35.0 | 43.3 | 53.7 | 62.1 | 66.8 | 66.3 | 60.1 | 48.0 | 37.9 | 28.6 | 45.9 |
| Mean daily range in temperature. | 16.2 | 16.8 | 18.6 | 20.2 | 19.3 | 17.6 | 17.5 | 16.2 | 17.6 | 18.1 | 17.4 | 16.0 | 17.6 |
| Greatest daily range in temperature. | 36.0 | 47.0 | 45.0 | 41.0 | 42.0 | 30.0 | 29.0 | 28.0 | 32.0 | 37.0 | 36.0 | 38.0 | 47.0 |
| Number of days with temperature 90° or above. | 0.0 | 0.0 | 0.0 | 0.3 | 1.0 | 2.7 | 5.6 | 3.0 | 2.1 | 0.0 | 0.0 | 0.0 | 14.7 |
| Number of days with temperature 32° or below. | 23.5 | 22.8 | 12.7 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .7 | 8.9 | 20.7 | 92.1 |
| Number of days with temperature 14° or below. | 3.1 | 5.8 | .4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 10.9 |
| Mean monthly and annual precipitation. | 2.95 | 3.41 | 4.07 | 3.53 | 3.87 | 4.51 | 6.01 | 3.87 | 3.81 | 3.66 | 2.92 | 3.20 | 45.81 |
| Maximum precipitation in 24 hours. | 2.23 | 2.52 | 2.80 | 3.00 | 2.70 | 4.90 | 14.75 | 2.86 | 5.27 | 3.50 | 3.00 | 2.00 | 14.75 |
| Mean monthly and annual snowfall. | 5.3 | 7.1 | 1.8 | T. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .2 | 1.9 | 16.3 |
| Precipitation on days with .01 inch or more. | .38 | .46 | .42 | .47 | .38 | .52 | .62 | .44 | .65 | .78 | .49 | .48 | .51 |
| Average number of days with precipitation of .01 inch or more. | 8.0 | 7.0 | 9.0 | 7.0 | 9.0 | 8.0 | 9.0 | 8.0 | 5.0 | 6.0 | 5.0 | 7.0 | 88.0 |
| Average number of days with snowfall of .10 inch or more. | 2.1 | 2.2 | .7 | .1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .4 | 1.0 | 6.5 |
| Average number of clear days. | 16.0 | 15.0 | 15.0 | 16.0 | 18.0 | 16.0 | 19.0 | 19.0 | 21.0 | 19.0 | 17.0 | 17.0 | 208.0 |
| Average number of partly cloudy days. | 6.0 | 6.0 | 7.0 | 7.0 | 8.0 | 9.0 | 9.0 | 9.0 | 5.0 | 5.0 | 7.0 | 6.0 | 84.0 |
| Average number of cloudy days. | 9.0 | 7.0 | 9.0 | 7.0 | 5.0 | 5.0 | 3.0 | 3.0 | 4.0 | 7.0 | 6.0 | 8.0 | 73.0 |
| Average number of days with hail. | .07 | 0.0 | .07 | .07 | .2 | .07 | .07 | .08 | .08 | 0.0 | 0.0 | 0.0 | .7 |
| Average number of days with sleet. | .6 | .6 | .9 | .07 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | .07 | .6 | 2.8 |
| Average number of days with thunderstorms. | .4 | .6 | .7 | 1.7 | 5.7 | 6.4 | 8.6 | 5.5 | 3.2 | .8 | .4 | .7 | 34.1 |
| Average number of days with fog. | 2.1 | 1.6 | 3.2 | 1.1 | 1.6 | .6 | .2 | .7 | 1.8 | 1.6 | 2.5 | 1.0 | 18.0 |
| Auroras (total in 14 years)..... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 1.0 | 1.0 | 0.0 | 1.0 | 5.0 |
| Prevailing wind direction..... | NW | NW | NW | SW | SE | SW | SW | SE | SW | NE | NW | SW | SW |
| Average date of last and first snowfall of .10 inch or more. | Last March 8th. | | | | | | First December 15th. | | | | | | |

TABLE XI.

RÉSUMÉ OF ANNUAL CLIMATIC DATA (1896—1915) AT ANNAPOLIS, MARYLAND.

(Temperatures in degrees Fahrenheit; precipitation in inches.)

| | 1896 | 1897 | 1898 | 1899 | 1900 | 1901 | 1902 | 1903 | 1904 | 1905 | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | Normal. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean annual temperature | 57.0 | 56.7 | 57.4 | 56.0 | 57.3 | 55.6 | ..... | ..... | 53.2 | (55.2) | (56.9) | 53.3 | 55.2 | 55.3 | 54.1 | 57.8 | 56.2 | 58.9 | 56.7 | 56.6 | 55.8 |
| Monthly maximum temperature | 94.0 | 94.0 | 98.0 | 95.0 | 100.0 | 105.0 | 98.0 | 95.0 | 96.0 | 96.0 | 95.0 | 92.0 | 96.0 | 95.0 | 93.0 | 99.0 | 95.0 | 100.0 | 99.0 | 97.0 | ..... |
| Monthly minimum temperature | 5.0 | 10.0 | 7.0 | — 6.0 | 5.0 | 10.0 | 12.0 | ..... | 2.0 | 2.0 | 10.0 | 6.0 | 10.0 | 9.0 | 8 | (15.0) | —3.0 | 12.0 | 7.0 | 19.0 | ..... |
| Mean daily maximum temperature | 63.6 | ..... | ..... | 64.2 | 65.6 | 64.2 | 64.8 | 63.5 | 61.7 | ..... | ..... | 60.5 | 62.0 | 62.9 | 59.0 | ..... | 65.1 | 68.2 | 66.0 | 64.9 | 63.9 |
| Mean daily minimum temperature | ..... | ..... | ..... | 47.9 | 49.0 | 47.1 | ..... | ..... | 45.0 | 46.7 | ..... | 46.1 | 48.3 | 47.7 | 48.3 | ..... | 47.2 | 49.5 | 49.2 | 48.2 | 48.1 |
| Mean daily range in temperature | ..... | ..... | ..... | 16.3 | 16.6 | 17.1 | ..... | ..... | 16.7 | ..... | ..... | 14.4 | 13.7 | 15.2 | 10.7 | ..... | 17.9 | 18.7 | 16.8 | 16.7 | 15.8 |
| Greatest daily range in temperature | 31.0 | 33.0 | *(29.0) | 34.0 | 35.0 | 45.0 | (34.0) | ..... | 39.0 | 36.0 | (37.0) | 35.0 | 38.0 | 41.0 | 40.0 | (39.0) | 47.0 | 47.0 | 37.0 | 33.0 | ..... |
| Number of days with temperature 90° or above | 31 | 4 | 40 | 25 | 49 | 42 | 22 | 17 | 15 | 14 | 17 | 5 | 17 | 20 | 6 | 39 | 26 | 31 | 38 | 7 | 23.4 |
| Number of days with temperature 32° or below | 85 | 45 | ..... | 77 | 79 | 86 | 79 | ..... | 114 | 98 | ..... | 80 | 86 | 79 | 88 | ..... | 90 | 62 | 90 | 87 | 81.7 |
| Number of days with temperature 14° or below | 10 | 1 | 4 | 16 | 14 | 5 | 3 | ..... | 14 | 14 | 5 | 8 | 6 | 2 | 4 | 0 | 16 | 1 | 14 | 0 | 7.4 |
| Number of days with mean temperature 42° or above between last 32° or below in spring and first 32° or below in autumn | 238 | 217 | 207 | 173 | 219 | 191 | 183 | 213 | 192 | 196 | 169 | 204 | 209 | 192 | 225 | 208 | 212 | 216 | 200 | 228 | 205 |
| Average annual precipitation | (33.25) | (45.00) | (34.98) | (44.70) | 41.44 | 53.62 | 56.62 | 54.04 | 50.26 | 50.83 | 51.63 | 66.59 | 52.50 | 50.33 | 52.45 | (37.38) | 42.38 | 36.21 | 40.24 | 41.26 | 47.18 |
| Average daily precipitation † | ..... | ..... | ..... | ..... | 0.58 | 0.62 | 0.67 | 0.61 | 0.60 | 0.49 | 0.45 | 0.57 | 0.49 | 0.61 | 0.58 | ..... | 0.42 | 0.34 | 0.38 | 0.37 | 0.51 |
| Greatest precipitation in 24 hours | ..... | 1.95 | 1.90 | 2.30 | 3.10 | 3.30 | 3.50 | 3.00 | 5.80 | 2.89 | 1.85 | 3.80 | 2.90 | 2.90 | 2.40 | 7.35 | 1.84 | 2.00 | 3.81 | 2.60 | ..... |
| Number of days with precipitation † | ..... | ..... | ..... | ..... | 71 | 87 | 85 | 88 | 84 | 103 | 116 | 117 | 97 | 83 | 91 | ..... | 101 | 105 | 106 | 112 | 96 |
| Snowfall (seasonal totals) | ..... | ..... | ..... | ..... | 27.5 | ..... | ..... | 6.0 | ..... | ..... | ..... | 33.0 | ..... | 35.5 | ..... | ..... | ..... | 28.0 | 22.8 | ..... | 25.0 |
| Number of clear days | ..... | 195 | ..... | 191 | 154 | ..... | ..... | 171 | 215 | 197 | 165 | 171 | 179 | 186 | 180 | ..... | ..... | 114 | 146 | 102 | 178 |
| Number of partly cloudy days | ..... | 93 | ..... | 111 | 120 | ..... | ..... | 5 | 33 | 79 | 101 | 83 | 110 | 92 | 90 | ..... | ..... | 39 | 50 | 62 | 67 |
| Number of cloudy days | ..... | 77 | ..... | 62 | 90 | ..... | ..... | 189 | 117 | 89 | 99 | 111 | 77 | 87 | 95 | ..... | ..... | 202 | 169 | 201 | 120 |
| Number of days with thunderstorms | 1 | 7 | 4 | 9 | 1 | 18 | 14 | 14 | 3 | 8 | 11 | 7 | 13 | 11 | 8 | 9 | 0 | 1 | 0 | 0 | 7 |
| Number of days with hail | 0 | 0 | 1 | 4 | 0 | 1 | 0 | 1 | 2 | 2 | 0 | 2 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0.9 |
| Number of days with sleet | 1 | 11 | 2 | 1 | 0 | 2 | 9 | 2 | 4 | 5 | 2 | 0 | 2 | 4 | 1 | 7 | 0 | 0 | 0 | 0 | 2.6 |
| Prevailing wind direction | ..... | ..... | ..... | NW | SW | SE | NW | NW | NW | NW | SW | SW | SW | SW | SE | S | S | S | NW | NW | NW |

* Interpolated values in parentheses. † Not including traces of rain or snow.

TABLE XII.

RÉSUMÉ OF ANNUAL CLIMATIC DATA (1895-1907) AT JEWELL, MARYLAND.

| | 1895 | 1896 | 1897 | 1898 | 1899 | 1900 | 1901 | 1902 | 1903 | 1904 | 1905 | 1906 | 1907 | Normal. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean annual temperature | 54.4 | 55.7 | ..... | 55.4 | 53.8 | 56.6 | 54.0 | 55.1 | 54.7 | 52.4 | 54.4 | 55.0 | (53.2) | 54.9 |
| Monthly maximum temperature | 95.0 | 97.0 | 93.0 | 99.0 | 90.0 | 100.0 | 100.0 | 95.0 | 94.0 | 93.0 | 93.0 | 92.0 | 92.0 | ..... |
| Monthly minimum temperature | — 2.0 | 6.0 | 6.0 | 5.0 | —14.0 | 4.0 | 7.0 | 5.0 | 4.0 | 4.0 | 0.0 | 8.0 | 3.0 | ..... |
| Mean daily maximum temperature | 63.1 | 61.3 | ..... | 64.6 | 63.4 | 65.9 | 62.5 | 63.8 | 63.2 | 60.9 | 63.5 | 64.0 | ..... ..... | 63.1 |
| Mean daily minimum temperature | 45.6 | 47.0 | 46.1 | 46.2 | 44.8 | 47.3 | 45.0 | 46.3 | 46.2 | 43.9 | 45.4 | ..... | ..... | 45.9 |
| Mean daily range in temperature | 17.5 | 17.3 | ..... | 18.4 | 18.6 | 18.6 | 16.9 | 17.5 | 17.0 | 17.0 | 18.1 | ..... | ..... | 17.6 |
| Greatest daily range in temperature | 37.0 | 42.0 | (36.0) | 36.0 | 39.0 | 47.0 | 38.0 | 39.0 | 37.0 | 34.0 | 36.0 | (39.0) | (45.0) | ..... |
| Number of days with temperature 90° or above | 21 | 26 | (†) | 29 | 13 | 36 | 16 | 11 | 13 | 9 | 7 | (†) | (†) | 14.7 |
| Number of days with temperature 32° or below | 97 | 96 | 85 | (67) | (76) | 87 | 97 | 85 | 80 | 115 | 102 | 86 | 85 | 92.1 |
| Number of days with temperature 14° or below | 13 | 10 | 9 | 5 | (†) | 14 | 12 | 7 | 6 | 18 | 18 | 6 | 8 | 10.9 |
| Annual precipitation | 30.79 | 33.19 | 58.68 | 40.69 | 42.52 | 42.05 | 43.89 | 49.92 | 44.64 | 37.84 | 43.40 | 46.36 | 49.44 | 45.81 |
| Average daily precipitation † | .46 | .49 | .64 | .47 | .50 | .51 | .56 | .55 | .49 | .50 | .40 | .41 | .45 | .51 |
| Greatest precipitation in 24 hours | 3.0 | 2.70 | 14.75 | 2.50 | 2.55 | 3.63 | 3.00 | 4.90 | 2.53 | 5.27 | 2.86 | 1.80 | 2.05 | *3.06 |
| Number of days with precipitation † | 80 | 68 | 91 | 87 | 85 | 83 | 78 | 90 | 92 | 70 | 95 | 114 | 109 | 88 |
| Snowfall (seasonal totals) | 30.5 | 1.5 | 7.5 | ..... | 47.2 | 20.5 | 6.5 | 8.0 | 2.5 | 13.9 | ..... | 14.5 | 22.2 | 16.3 |
| Number of clear days | 231 | 209 | 208 | 206 | 209 | 226 | 229 | 212 | 202 | 191 | 175 | 168 | 169 | 208 |
| Number of partly cloudy days | 06 | 71 | 77 | 78 | 68 | 57 | 65 | 95 | 85 | 105 | 126 | 122 | 78 | 84 |
| Number of cloudy days | 08 | 86 | 80 | 81 | 57 | 80 | 71 | 58 | 78 | 07 | 64 | 75 | 57 | 73 |
| Number of days with thunderstorms | 31 | 37 | 38 | 26 | 35 | 39 | 33 | 33 | 38 | 35 | 41 | 38 | 23 | 34 |
| Number of days with hail | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 1 | 0 | .7 |
| Number of days with sleet | 4 | 3 | 1 | 3 | 0 | 0 | 1 | 5 | 0 | 7 | 5 | 6 | 0 | 2.8 |
| Number of days with auroras | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | (Total) 5 |
| Number of days with fog | 23 | 10 | 13 | 19 | 19 | 14 | 17 | 19 | 25 | 13 | 21 | 22 | 14 | 18 |
| Prevailing wind direction | NW | SW | NW | NW | NE | SW | SW | NW | SW | NE | SW | SW | SW | SW |

† Not including traces of rain or snow. * Omitting the phenomenal fall of 14.75 inches in 1897, the average of the greatest daily rainfalls is 3.06. ‡ Interpolated values in parenthesis.

# THE HYDROGRAPHY OF ANNE ARUNDEL COUNTY

BY

B. D. WOOD

## Introductory

Anne Arundel County, Maryland, is located on the west shore of Chesapeake Bay, and has a land area of 442 square miles. The streams within the county are all tributary to Chesapeake Bay, either directly or indirectly through the Patapsco and Patuxent rivers which form the larger portion of the northern and western boundaries, respectively, of the county.

The maximum elevation, with the exception of a few limited areas, does not exceed 250 feet above sea level. Therefore, the fall of the various streams is small, except in headwaters, and many are in the influence of tide water nearly to their source, the extreme range of tide along the shores of the county being about 2 feet.

No data are available in regard to the power which has been developed in the county, but owing to the small flow and slope of the streams, they are necessarily limited in number and size, and future developments must be limited to small plants for local use.

No measurements have been made on the streams within the limits of the county. Gaging stations, however, were maintained on the Patapsco River at Woodstock, Md., from 1896 to 1909, inclusive, and on the Patuxent at Laurel, Md., from 1896 to 1898, inclusive. Rainfall records show an annual precipitation of about 45 inches, as noted in the following table:

| | |
|---|---|
| Baltimore | 38 inches |
| Annapolis | 50 " |
| Solomons | 38 " |

Following is a gazetteer of the streams of the county, not including the tidal estuaries. This gives a brief description of each stream as taken from the general county map, published in 1907 by the Maryland Geological Survey in cooperation with the U. S. Geological Survey.

## GAZETTEER OF STREAMS[1]

*Bacon Ridge Branch.*—Rises in the western part of the county, at altitude 140 feet above sea level; flows southeastward 5½ miles to the head of South River, through which it is tributary to Chesapeake Bay.

*Beards Creek.*—Rises northwest of Birdsville, at altitude about 140 feet above sea level; flows northeastward into South River (tributary to Chesapeake Bay); length above tide water, 2½ miles.

*Blackwalnut Creek.*—A stream, about 1 mile long, flowing southeastward into Chesapeake Bay, about 1 mile southwest of Bay Ridge.

*Brewer Creek.*—A small stream flowing north of east into Severn River (tributary to Chesapeake Bay), just south of Brewer Point.

*Broad Creek.*—Rises near Crownsville, at altitude about 100 feet above sea level; flows east of south 2½ miles, then somewhat west of south into South River (tributary to Chesapeake Bay); tidal in lower course; length above tide water, nearly 4 miles.

*Cabin Branch.*—Rises half a mile southwest of Shipley, at altitude 150 feet above sea level; flows northeastward through Curtis Creek and Bay to Patapsco River (tributary to Chesapeake Bay); length above tide water, about 4 miles. Curtis Creek and Bay are tidal estuaries.

*Cattail Creek.*—A stream about 3 miles long, flowing eastward into Magothy River (tributary to Chesapeake Bay); length above tide water, about 2 miles.

*Clements Creek.*—A stream about 1 mile above tide water, flowing northeastward into Severn River.

[1] Except where otherwise stated the only authority for the descriptions given is the county map. The gazetteer does not include the so-called creeks and rivers which are merely tidal estuaries.

*Cockey Creek.*—Rises half a mile southeast of Jacobsville, at altitude about 80 feet above sea level; flows southward 1 mile, then southwestward 2 miles into Magothy River; length above tide water, a little over a mile.

*Deep Creek.*—A stream somewhat more than a mile long above tide water, flowing northeastward into Magothy River (tributary to Chesapeake Bay), between Adams Point and Persimmon Point.

*Deep Ditch Branch.*—An intermittent stream flowing in general eastward through Little Round Bay Creek to Little Round Bay on Severn River (tributary to Chesapeake Bay).

*Deep Run.*—Rises in Howard County, ½ mile east of Jonestown, at altitude about 460 feet above sea level; flows east of south about 4 miles, then to the east and northeast to its junction with Patapsco River, north of Patapsco in Anne Arundel County; for lower 4 miles of course forms the boundary between Howard and Anne Arundel counties; called Deep Creek in Howard County.

*Dorsey Run.*—Rises near Pfeiffer Corners in Howard County, at altitude about 380 feet above sea level; flows in general somewhat east of south to its junction with Little Patuxent River (tributary to Patuxent River), which discharges to Chesapeake Bay about 1 mile south of Annapolis Junction; length, about 8 miles; fall, nearly 300 feet, of which 200 feet is made in the first 2 miles in Howard County. See Laurel Sheet, U. S. G. S.

*Forked Creek.*—A stream about 1 mile long above tide water, flowing northward into Magothy River (tributary to Chesapeake Bay).

*Gales Creek.*—Rises about ½ mile northeast of Owensville, at altitude 140 feet above sea level; flows eastward and southeastward into West River, through which it is a tributary to Chesapeake Bay. West River is a tidal estuary.

*Gumbottom Branch.*—A small stream flowing eastward into Plum Creek, which discharges to Severn River (tributary to Chesapeake Bay).

*Hall Creek.*—Rises near Friendship in the southeastern part of the county, at altitude 150 feet above sea level; takes a general southwesterly course to its junction with Patuxent River (tributary to Chesapeake

Bay); length, about 8 miles, of which only the upper 2½ miles at the head is in Anne Arundel County.

*Holly Creek.*—A stream about 1 mile long, flowing northward into Patapsco River (tributary to Chesapeake Bay), near Pumphrey.

*Jabez Branch.*—A small stream flowing northeastward into Severn River near the mouth of Severn Run.

*Little Patuxent River.*—See Patuxent River, Little.

*Luce Creek.*—A stream about ½ mile long above tide water, flowing northeastward into Severn River.

*Lyons Creek.*—Rises ½ mile southwest of Lothian postoffice in the southern part of the county, at altitude 160 feet above sea level; flows east of south about 3½ miles, then southwestward 6 miles to its junction with Patuxent River (tributary to Chesapeake Bay); forms part of boundary between Anne Arundel and Calvert counties.

*Magothy River.*—Rises 1 mile southwest of Elvaton, at altitude 80 feet above sea level; flows northeastward 1 mile, then southeastward to its junction with Chesapeake Bay; lower part of river is a tidal estuary.

*Magothy River, Little.*—Rises ¾ mile south of Deep Creek; flows southeastward about ½ mile and to the east and northeast into Chesapeake Bay, just below the mouth of Magothy River.

*Marley Creek.*—Rises about 1¼ miles west of Elvaton, at altitude 120 feet above sea level; takes a general northeasterly course to Curtis Creek and Bay, through which it is tributary to Patapsco River (tributary to Chesapeake Bay); Curtis Bay and Creek are tidal estuaries.

*Mill Creek.*—Rises in the southern part of the peninsula between Magothy and Severn rivers, at altitude 80 feet above sea level; flows southeastward through Whitehall River to Chesapeake Bay; Whitehall River is a tidal estuary. Length of Mill Creek above tide water, about 1¾ miles.

*Mill Creek.*—Rises north of Arnold, at altitude 86 feet above sea level; flows northward into Magothy River; length above tide water, about 1½ miles.

*Muddy Creek.*—Formed by two chief branches which unite about ½ mile above tide water and flow to the east and south, and then northeastward to Rhodes River, a northern arm of West River on Chesapeake Bay. The southern branch of Muddy Creek rises 1 mile northwest of West River postoffice, at altitude 200 feet above sea level, and flows in general somewhat north of east.

*North River.*—Rises in the western part of the county, at altitude about 140 feet above sea level; flows east and southeast to the head of South River, through which it is tributary to Chesapeake Bay; principal tributary, Tarmans Branch.

*Old Man Creek.*—A stream about 1½ miles long, rising near Earleigh Heights and flowing eastward into Magothy River (tributary to Chesapeake Bay); length above tide water, about 1 mile.

*Patapsco River.*—Formed by the junction of North and South branches in Carroll County. The North Branch, which drains the larger area and is therefore considered the continuation of the main stream, is formed at Patapsco by the junction of its East and West branches, of which the eastern branch drains the larger area. The East Branch rises about ½ mile northwest of Greenmount station on the Baltimore and Western Maryland Railroad, at altitude about 810 feet above sea level; flows in general west of south to Patapsco, where it receives the West Branch and takes the name North Branch Patapsco. From this junction the North Branch flows very irregularly southward to its junction with the South Branch, whence its course is in general southeastward to Chesapeake Bay. The North Branch forms the junction between Baltimore and Howard and Baltimore and Anne Arundel counties; the total area drained by the Patapsco measures 350 square miles (?), and lies almost entirely above the fall line. The basin contains no lakes or artificial reservoirs, and the flow of the stream is variable; principal tributaries in Anne Arundel County, Deep and Stony runs, and small streams which discharge into the lower part of the river through Curtis, Stony, and Rock creeks, all of which are tidal estuaries. The heads of the creeks north of

Anne Arundel County are shown on the Baltimore and Howard County maps. Gaging station at Woodstock (1896-1909).

*Patuxent River.*—Rises in Montgomery and Howard counties, its head waters reaching altitudes of about 800 feet above sea level; flows southeastward and then southward, forming the boundary line between the counties of Howard, Anne Arundel, and Calvert on its left, and Montgomery, Prince George's, and St. Mary's on its right; discharges into the Chesapeake 18 or 20 miles above the mouth of the Potomac. It drains an area of about 960 square miles and its length, measured in a straight line, is about 80 miles. It is navigable for 40 or 50 miles from its mouth and crosses the fall line near Laurel. The flow of the stream is very variable; freshets are heavy and sudden, and flow during the dry season is very small; principal tributaries in Anne Arundel County, Little Patuxent, Rock Branch, and Lyons Creek. Gaging station at Laurel (1896-1898).

*Patuxent River, Little.*—Rises in Howard County, 1 mile east of Mountview, at altitude 560 feet above sea level; takes a general southeasterly course to its junction with Patuxent River, ½ mile northwest of Priest Bridge; crosses into Anne Arundel County at Savage station on Baltimore and Ohio Railroad; length, about 30 miles; fall, 520 feet, of which 440 feet is made in the 20 miles above the fall line at Savage; principal tributaries, Middle Patuxent River in Howard County, and Dorsey Run, Rogue Harbor Branch, and Towser's Branch in Anne Arundel County.

*Piny Run.*—Rises in the western part of the county, at altitude about 220 feet above sea level; flows northeastward 3½ miles into Deep Run, through which it is tributary to Patapsco River (tributary to Chesapeake Bay); fall, about 180 feet.

*Plum Creek.*—A small stream flowing northeastward into Severn River (tributary to Chesapeake Bay); tidal in lower course; tributary, Gumbottom Branch.

*Rock Branch.*—Rises in the southern part of the county near Lothian postoffice, at altitude 180 feet above sea level; flows in general north of

west into Patuxent River (tributary to Chesapeake Bay); length, about 5 miles; fall, about 170 feet.

*Rogue Harbor Branch.*—Rises in the western part of the county, at altitude about 230 feet above sea level; flows somewhat east of south to its junction with Little Patuxent River (tributary through Patuxent River to Chesapeake Bay) near Patuxent station; length, about 5½ miles; fall, 160 feet.

*Saltworks Creek.*—A stream about 1 mile above tide water, flowing northeastward into Severn River.

*Sawmill Creek.*—Rises ½ mile southeast of Friendship Church, at altitude 100 feet above sea level; flows in general northeastward through Furnace Creek and Curtis Creek and Bay to Patapsco River (tributary to Chesapeake Bay). Furnace and Curtis creeks are tidal estuaries.

*Severn River.*—Rises in the western part of the county, about 2 miles west of Severn, at altitude 180 feet above sea level; flows in general southeastward into Chesapeake Bay, which it enters just below Annapolis; called Severn Run in upper part of course above tide water; principal tributaries, Jabez Branch, Plum Creek, and a number of small streams, which enter through estuarian creeks—Brewer, Clements, Saltworks, Luce, and Weems—northwest of Annapolis; lies entirely below the fall-line.

*South River.*—Formed at the head of tide water by the junction of North River and Bacon Ridge Branch (q. v.) below this junction; receives a number of small streams which enter from tidal estuaries.

*Spa Creek.*—A stream ½ mile long above tide water, flowing eastward into Severn River at Annapolis.

*Stony Run.*—Rises 1½ miles west of Severn, at altitude about 170 feet above sea level; flows in general somewhat east of north to its junction with Patapsco River (tributary to Chesapeake Bay) north of Patapsco; length, about 6 miles; fall, about 150 feet.

*Tarmans Branch.*—Rises 1 mile northwest of St. Stephens Church, in the western part of the county, at altitude 110 feet above sea level; flows southeastward 3½ miles into North River (tributary through South River to Chesapeake Bay).

*Thomas Branch.*—A stream, about 1 mile long, flowing southwestward into Patuxent River 1 mile above Duvall Bridge.

*Towser's Branch.*—Rises 1 mile west of Sappington, in the western part of the county, at altitude 200 feet above sea level; flows in general west of south to its junction with Little Patuxent River (tributary through Patuxent River to Chesapeake Bay) west of Conaways; length, 4½ miles; fall, 150 feet.

*Tracy Branch.*—Rises ½ mile northwest of West River postoffice, at altitude 180 feet above sea level; flows southeastward into Chesapeake Bay; length above tide water, about 5 miles.

*Turon Branch.*—Rises near Bristol in the southwestern part of the county, at altitude 80 feet above sea level; flows northwestward about 1 mile and southwestward 2 miles into Patuxent River; fall, about 70 feet.

*Weems Creek.*—A stream about 1 mile long above tide water, flowing eastward and northeastward into Severn River.

*Whitehall Creek.*—Rises on the Peninsula between Magothy and Severn rivers, at altitude 114 feet above sea level; flows southeastward and southward through Whitehall River to Chesapeake Bay. Whitehall River and a lower part of the creek are tidal estuaries.

# THE MAGNETIC DECLINATION IN ANNE ARUNDEL COUNTY

BY

L. A. BAUER

## Introductory

Values of the magnetic declination of the needle, or of the "variation of the compass," as observed by the Maryland Geological Survey and the United States Coast and Geodetic Survey at various points within the county, are given in Table I.

For a general description of the methods and instruments used, reference must be made to the "First Report upon Magnetic Work in Mary-

*Table I.—Magnetic Declinations in Anne Arundel County*

| Station | Latitude N | Longitude W. of Gr. | Date when observed | Magnetic Declination (West) | | | | | Observer |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Value observed | Reduced to | | | | |
| | | | | | 1900.0 | 1905.0 | 1910.0 | 1915.0 | |
| | ° ′ | ° ′ | | ° ′ | ° ′ | ° ′ | ° ′ | ° ′ | |
| Fair Haven | 38 45.4 | 76 33.4 | 1897.5 | 5 23.2 | 5 30.7 | 5 49 | 6 14 | 6 37 | L. A. Bauer, Md. G. S. |
| Marriott | 38 52.4 | 76 36.6 | 1849.4 | 2 05.0 | 5 14 | 5 32 | 5 57 | 6 20 | Observers, C. & G. S. |
| Annapolis, Naval Academy | 38 58.9 | 76 29.1 | 1896.8 | 5 16.1 | 5 25.7 | 5 44 | 6 09 | 6 32 | L. A. Bauer, Md. G. S. |
| Annapolis, South Meridian Stone | 38 59.1 | 76 29.5 | 1900.5 | 5 30.8 | 5 29.4 | 5 47 | 6 12 | 6 35 | J. B. Baylor, C. & G. S. |
| Annapolis, North Meridian Stone | 38 59.1 | 76 29.5 | 1900.5 | 5 34.8 | 5 33.4 | 5 51 | 6 16 | 6 39 | J. B. Baylor, C. & G. S. |
| | Mean | for An | napolis | | 5 29.5 | 5 47 | 6 12 | 6 35 | |
| Taylor | 38 59.8 | 76 28.0 | 1847.4 | 2 18.0 | 5 36 | 5 54 | 6 19 | 6 42 | Observers, C. & G. S. |
| Webb | 39 05.3 | 76 40.5 | 1897.5 | 5 02.3 | 5 09.7 | 5 28 | 5 53 | 6 16 | L. A. Bauer, Md. G. S. |
| Bodkin Light | 39 08.0 | 76 25.5 | 1847.3 | 2 01.9 | 5 15 | 5 33 | 5 58 | 6 21 | Observers, C. & G. S. |

*Explanations.*—The date of observation is given in years and tenths of ; January 1, 1900 would accordingly be expressed by 1900.0 and similarly with regard to January 1, 1905 or 1910 or 1915.

land" (Md. Geol. Survey, vol. i, pt. v, 1897). In the Second Report (Md. Geol. Survey, vol. v, pt. i, 1905), the various values collected were reduced to January 1, 1900 ; they are now given also for January 1, 1905, and 1910 and 1915. The First Report gives likewise an historical account

of the phenomena of the compass needle and discusses fully the difficulties encountered by the surveyor on account of the many fluctuations to which the compass needle is subject. To these reports the reader is referred for any additional details.

### Meridian Line

At the request of the State Geologist, the superintendent of the Coast and Geodetic Survey detailed Mr. J. B. Baylor, in 1900, to establish a surveyor's meridian line at the county seat, Annapolis. The line was located on the Naval Academy grounds in the large open space south of the naval cemetery, and was marked by two stone posts, each bearing a brass cap lettered U. S. C. & G. S. The north stone is 93 feet from the cemetery road, 190 feet from Severn county road, and about 300 feet from the south stone.

The latitude of the Naval Academy Observatory is 38° 58′.9 and the longitude 76° 29′.1 W. of Greenwich, or 31′.9 E. of Washington. To obtain true local mean time, or solar time, subtract from Eastern or Standard time 5 minutes and 56 seconds.

### Descriptions of Stations

*Fair Haven, 1897.*—On the hill not far from the steamboat landing.

*Marriott, 1849.*—Near the triangulation station of the Coast Survey (1846 and 1849).

*Annapolis, 1896.*—On the Naval Academy grounds, in the open area near the observatory; 45 paces west-northwest of observatory and 62 paces northeast of Herndon monument. Site was chosen by Professor Terry, in charge of the physical department of the academy.

*Annapolis, 1900.*—Observations were made over both ends of the meridian line located on the Naval Academy grounds, in the large open space south of the naval cemetery. The north stone is 93 feet from the cemetery road, 190 feet from Severn county road, and about 300 feet from the south stone.

*Taylor, 1847.*—Near the Coast Survey triangulation station of 1847.

*Webb, 1897.*—Near the 1897 scaffold of the triangulation station, about 94½ feet southeast from granite post marking the station. This is near the site of Coast and Geodetic Survey magnetic station of 1868.

*Bodkin Light, 1847.*—Near the Coast Survey triangulation station of 1847.

## CHANGES IN THE MAGNETIC DECLINATION

The following table is reproduced from page 483 of First Report cited, 3′ being added to the original figures in order to refer them to the Annapolis south meridian stone; the table has also been extended to 1915.

*Table II.—Showing the Change in the Magnetic Declination at Annapolis from 1700 to 1915*

| Year (Jan. 1) | Needle pointed | Year (Jan. 1) | Needle pointed | Year (Jan. 1) | Needle pointed | Year (Jan. 1) | Needle pointed |
|---|---|---|---|---|---|---|---|
| | ° ′ | | ° ′ | | ° ′ | | ° ′ |
| 1700 | 5 35 W | 1750 | 2 41 W | 1800 | 0 45 W | 1850 | 2 27 W |
| 05 | 5 24 W | 55 | 2 21 W | 05 | 0 45 W | 55 | 2 45 W |
| 10 | 5 12 W | 60 | 2 04 W | 10 | 0 46 W | 60 | 3 05 W |
| 15 | 4 57 W | 65 | 1 49 W | 15 | 0 50 W | 65 | 3 24 W |
| 20 | 4 39 W | 70 | 1 32 W | 20 | 0 57 W | 70 | 3 45 W |
| 25 | 4 21 W | 75 | 1 17 W | 25 | 1 07 W | 75 | 4 05 W |
| 30 | 4 01 W | 80 | 1 06 W | 30 | 1 20 W | 80 | 4 24 W |
| 35 | 3 41 W | 85 | 0 56 W | 35 | 1 33 W | 85 | 4 41 W |
| 40 | 3 21 W | 90 | 0 50 W | 40 | 1 51 W | 90 | 4 59 W |
| 45 | 3 01 W | 95 | 0 47 W | 45 | 2 09 W | 95 | 5 15 W |
| 1750 | 2 41 W | 1800 | 0 45 W | 1850 | 2 27 W | 1900 | 5 29 W |
| | | | | | | 05 | 5 47 W |
| | | | | | | 10 | 6 12 W |
| | | | | | | 15 | 6 35 W |

*The declination is west over the county, and during the period 1905 to 1915 it increased at the average annual rate of 5 minutes.*

With the aid of the figures in Table II the surveyor can readily ascertain the amount of change of the needle between any two dates. As far as practical purposes are concerned, the change thus derived may be taken the same over the county. It must be emphasized, however, that when applying the quantities thus found in the re-running of old lines, the surveyor should not forget that the table cannot attempt to give the correction to be allowed on account of the error of the compass used in the original survey.

To reduce an observation of the magnetic declination to the mean value for the day of 24 hours, apply the quantities given in the table below with the sign as affixed:

| Month | 6 A. M. | 7 | 8 | 9 | 10 | 11 | Noon | 1 | 2 | 3 | 4 | 5 | 6 P. M. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ′ | ′ | ′ | ′ | ′ | ′ | ′ | ′ | ′ | ′ | ′ | ′ | ′ |
| January | −0.1 | +0.2 | +1.0 | +2.1 | +2.4 | +1.2 | −1.1 | −2.5 | −2.6 | −2.1 | −1.3 | −0.2 | +0.2 |
| February | +0.6 | +0.7 | +1.5 | +1.9 | +1.4 | −0.1 | −1.5 | −2.1 | −2.5 | −2.0 | −1.2 | −0.8 | −0.4 |
| March | +1.2 | +2.0 | +3.0 | +2.8 | +1.6 | −0.6 | −2.5 | −3.4 | −3.7 | −3.3 | −2.3 | −1.2 | −0.5 |
| April | +2.5 | +3.1 | +3.4 | +2.6 | +0.8 | −2.1 | −4.0 | −4.1 | −4.2 | −3.6 | −2.3 | −1.2 | −0.2 |
| May | +3.0 | +3.8 | +3.9 | +2.6 | +0.1 | −2.4 | −4.0 | −5.0 | −4.5 | −3.6 | −2.3 | −0.9 | +0.1 |
| June | +2.9 | +4.4 | +4.4 | +3.3 | +1.1 | −2.0 | −3.6 | −4.5 | −4.5 | −3.8 | −2.6 | −1.2 | −0.2 |
| July | +3.1 | +4.6 | +4.9 | +3.9 | +1.8 | −1.2 | −3.4 | −4.4 | −4.7 | −4.2 | −2.8 | −1.3 | −0.3 |
| August | +2.9 | +4.9 | +5.4 | +3.7 | +0.4 | −2.8 | −4.7 | −5.1 | −4.9 | −3.7 | −1.9 | −0.6 | +0.3 |
| September | +1.8 | +2.8 | +3.4 | +2.5 | +0.3 | −2.7 | −4.4 | −4.6 | −4.2 | −4.0 | −1.4 | −0.3 | −0.1 |
| October | +0.5 | +1.6 | +3.1 | +2.8 | +1.4 | −1.0 | −2.7 | −3.3 | −3.4 | −2.4 | −1.3 | −0.4 | −0.4 |
| November | +0.5 | +1.2 | +1.7 | +1.8 | +1.1 | −0.5 | −2.0 | −2.7 | −2.6 | −1.8 | −1.0 | −0.2 | +0.2 |
| December | +0.2 | +0.3 | +0.8 | +1.8 | +1.8 | 0.0 | −1.6 | −2.4 | −2.3 | −1.8 | −1.1 | −0.3 | +0.1 |

# THE FORESTS OF ANNE ARUNDEL COUNTY

BY

F. W. BESLEY

## Introductory

A forest survey of Anne Arundel County was made by the State Forester in 1909 for the purpose of ascertaining as accurately as possible forest conditions in the county, and securing detailed information in regard to the character and stand of timber, the uses of the forest, the methods of cutting, the amount of timber now being cut, and the damage by fire and other destructive agencies. The results of this study are embodied in this report, which is largely supplemented by the accompanying forest map. It is such information that is needed to furnish an intelligent basis for dealing with local forest problems and evolving plans calculated to give the best permanent results in handling the wood and timber of the county.

These timber resources are a valuable asset, and with the large area of woodland capable, under proper management, of producing timber of excellent quality, these resources are not only of great value to the county, but could be made much more so by adopting a judicious system of forest management. The State Board of Forestry, which was organized in 1906 for the purpose of giving reliable and accurate information regarding the forests of the state, and of cooperating with the individual owners in the management of their lands and the sale of forest products, has completed the study of the forest conditions of the state by counties. It is prepared not only to give detailed information concerning the forest resources of each county, but also to assist private owners in handling their timberland and woodlot problems.

## THE DISTRIBUTION OF THE FORESTS

The wooded area of the county comprises 34 per cent of the total land area. The forests are rather uniformly distributed with a higher percentage of woodlands in the central and north-central part of the county than is found in the southern and extreme northern parts, where the land is more generally cultivated. The most notable feature of forest distribution is that the forests are invariably found along the ravines and streams, often, however, extending back upon the flat, higher lands. The soil is usually very light, and where steep slopes occur it washes badly, which accounts for the presence of a forest growth along these ravines and slopes. Such forests are in reality protection forests, which serve at the same time for the production of timber. The forest areas have been continually reduced and are now confined almost entirely to the non-agricultural lands. It is not likely that the per cent of woodland, except in the north-central portion, will be much further reduced under present conditions.

As a rule the woodlands are in small irregular patches and owned almost exclusively by farmers. The county was originally almost entirely covered with hardwood forests intermingled with small patches of Pine. As the population increased and the settlements advanced from the water courses, the forests rapidly diminished in area until about 50 years ago, when the turning point was reached, and since that time more land has grown up in forests than has been cleared. In recent years there has been increased activity in clearing lands in the northern part of the county, especially near the railroads, but this has been more than offset by the lands growing up in Pine along the Patuxent River and elsewhere. As a rule, these Pine forests represent the land that was once cleared for agricultural crops, and later abandoned. The light-seeded Pine quickly took possession of such areas, and the age of the forest is a good index of the time when the land ceased to be cultivated.

## THE DESCRIPTION OF THE FORESTS

The forests are very largely of the hardwood type, consisting of Oaks, Chestnut, Hickory, Gum, Yellow Poplar, Maple, and a variety of other species in varying proportions.

The Gum, particularly the Red or Sweet Gum, is found on the wet soils usually associated with Maple, Black Gum and Beech, while the Yellow Poplar and the more valuable Oaks are found on the lower slopes, Chestnut usually occupying the higher and dryer situations.

The Pine stands comprise but 23 per cent of the total forest area. There are two kinds of Pine found in the county, the more common one being the Scrub Pine, "Pinus virginiana," commonly called Spruce Pine, and Pitch Pine, or "Pinus rigida," often referred to as Foxtail Pine. The Scrub Pine occupies the higher and dryer soils and is found generally distributed along the hills near the Patuxent River and through the central part of the county; while the Pitch Pine is generally found on the moister sandy soils, particularly in the section forming a triangle, the points of which would be Patuxent, Glenburnie and Earleigh Heights. The variety of soil and difference in moisture conditions give rise to a greater variety in the hardwood species represented and their relative distribution.

The demand for cleared land in the northern end of the county has led to a great deal of clean cutting and clearing, while in the south very little clear cutting has been done. Everywhere the woodlands have been continually culled for the best of the timber, the inferior species remaining to constitute the present growing stock. Not only has there been great permanent injury to the future production of the forest by this system of culling, but fires have frequently followed the cutting operations, doing still further damage and leaving little of promise for a new forest. It is probable that this destructive method of handling the forest has reduced production to less than one-third of what the forests are capable of producing under proper management. A large per cent of the farms in the county are rented to tenants. In the southern part of the county the

rented farms comprise 80 per cent, while in the central and northern sections it runs about 50 per cent. Tenants, by nature of their tenure, could not be expected to take the same care of the woodlands as the owners. Under established custom the tenant has the use of the woodland for all purposes connected with the farm, and since he has no interest in the future of the forest he could not be expected to regard it in the same way as the owner, who would look upon it as a permanent investment.

This presents a problem in forest management that is difficult to handle. The solution must be found in a changed sentiment toward the forests on the part of the landowners, which will then be reflected through the tenants in their treatment of the forest. In other words, so long as the landowner himself does not fully appreciate the value of timber and the possibilities of young growth it will be out of the question for him to exact the proper recognition of the forest's value from the tenants. The growing of timber is, in the last analysis, just as much the growing of a crop as that of growing corn, the difference being in the length of time required to produce it. Eventually the handling of the woodland on the farm by the tenant will be regulated in somewhat the same way as the handling of other crops. It does not seem unreasonable that there should be some definite agreement between the tenant and the landowner, as a part of the lease of the property, which will guarantee better management of the woodlands on a farm.

The good transportation facilities both by water and by rail—there being four freight lines crossing the county and a fifth along the border—has rendered accessible all of the woodlands, resulting in rather close cutting. This accounts in a large measure for the generally poor condition of the woodlands so far as their commercial value is concerned. Excellent timber has been produced in the county and can be produced again under the same favorable conditions of soil and climate. The present wooded area consists almost entirely of lands that are not suitable for any other crop. Under a proper system of management they could be made very productive.

FIG. 1.—VIEW OF ROLLING FARM LANDS AND WOOD LOTS, NEAR BIRDSVILLE.

FIG. 2.—VIEW OF A MIXED OAK AND CHESTNUT FOREST PROTECTED FROM FIRES.

## THE STAND OF THE TIMBER AND ITS VALUE

In the forest survey of the county, each wooded area containing five acres or more was located on a map and the stand and value of the merchantable timber estimated. The reader is referred to the map for details.

In the following table will be found a summary of the acreage, stand and value by election districts:

*Wooded Area, Stand and Value of Saw Timber by Election Districts*

| Dist. No. | Total Area | Wooded Area | Percent Wooded | Stand of saw timber in board feet (Doyle log rule). All trees more than nine inches in diameter | | | Stumpage value | | |
|---|---|---|---|---|---|---|---|---|---|
| | Acres | Acres | % | Hardwood M bd. ft. | Pine M bd. ft. | Total M bd. ft. | Hardwood $4.50 per M | Pine $5 per M | Total |
| 1 | 46,200 | 9,401 | 20 | 16,342 | 391 | 16,733 | $73,539 | $1,955 | $ 75,494 |
| 2 | 49,500 | 20,290 | 41 | 26,309 | 1,087 | 27,396 | 118,390 | 5,435 | 123,826 |
| 3 | 60,610 | 26,100 | 43 | 25,280 | 718 | 25,998 | 113,760 | 3,590 | 117,350 |
| 4 | 54,700 | 25,472 | 46 | 21,756 | 3,814 | 25,570 | 97,902 | 19,070 | 116,972 |
| 5 | 24,290 | 5,400 | 22 | 17,769 | 175 | 17,944 | 79,961 | 875 | 80,835 |
| 6 | 39,200 | 5,603 | 14 | 14,858 | 18 | 14,876 | 66,861 | 90 | 66,951 |
| The County | 274,500 | 92,266 | 34 | 122,314 | 6,203 | 128,517 | $550,413 | $31,015 | $581,428 |

## THE COMMERCIAL TYPES

The wooded area of the county is classified in three general forest types. viz.: The Hardwood type, represented on the map by the red color; the Pine, represented by green; and the Mixed Hardwood and Pine type, represented by red and green. Each of these main types was subdivided into subordinate types represented by letters, each of these representing differences in the stand of timber per acre.

*Hardwood Types.*—The hardwood types are divided into three classes indicated by differences in coloring. The merchantable hardwoods represent areas containing trees of mature size where the stand of timber per acre is sufficient to warrant logging operations. This type is subdivided into two classes according to the stand of timber per acre.

The next class is that of the culled hardwoods, representing areas that have been more or less cut over, and where the stand of timber is not con-

sidered heavy enough to make lumbering operations entirely practicable. Many of these stands contain scattered trees of large size and considerable value, but in most cases they represent young stands not yet mature. The culled hardwoods are further subdivided into three classes depending upon the stand of timber per acre.

The third class of hardwoods, the hardwood saplings, represents young stands under 20 feet in height and containing nothing of merchantable value.

*Pine Types.*—The pure pine forests are divided into two types—one the merchantable type, in some cases Scrub, or Pitch Pine, in which the stand of timber is represented in cords because these species do not ordinarily attain saw timber size; the other the sapling size, which is represented by sapling growth under 20 feet in height and less than four inches in diameter, none of which is large enough for cordwood.

*Mixed Types.*—In addition to the pure hardwood and pure pine stands, there are found in certain sections, particularly in the central part of the county, areas in which the hardwood is associated with pine to form a mixed type. These, like the pure pine types, are divided into two classes —one represented by timber of merchantable size, the other by trees of sapling or small pole size which have not reached merchantable dimensions.

A reference to the map, and to the legend which shows the approximate stand of timber of the different types, will give a very good idea of the location, character and value of the wooded areas throughout the county. This information should be of particular value to the buyers of timber who are endeavoring to locate suitable tracts for their timber operations.

## THE FOREST TREES

There are a considerable number of forest trees indigenous to the county. Many of them are of commercial importance; others are found only sparingly. The list below contains all species native to the county which normally reach a height of fifteen feet or more.

CONIFERS

| | *Common Name* | *Botanical Name* |
|---|---|---|
| 1. | Scrub Pine | *Pinus virginiana* (Mill.). |
| 2. | Pitch Pine | *Pinus rigida* (Mill.). |
| 3. | Shortleaf Pine | *Pinus echinata* (Mill.). |
| 4. | Loblolly Pine | *Pinus taeda* (Linn.). |
| 5. | Red Cedar | *Juniperus virginiana* (Linn.). |
| 6. | White Cedar | *Chamaecyparis thyoides* (Linn.). |

HARDWOODS

| | *Common Name* | *Botanical Name* |
|---|---|---|
| 7. | Black Walnut | *Juglans nigra* (Linn.). |
| 8. | Bitternut Hickory | *Hicoria minima* (Marsh) Britton. |
| 9. | Mockernut Hickory | *Hicoria alba* (Linn.) Britton. |
| 10. | Pignut Hickory | *Hicoria glabra* (Mill.) Britton. |
| 11. | White Willow | *Salix alba* (Linn.). |
| 12. | Black Willow | *Salix nigra* (Marsh). |
| 13. | Brittle Willow | *Salix fragilis* (Linn.). |
| 14. | Largetooth Aspen | *Populus grandidentata* (Michx.). |
| 15. | White Poplar | *Populus alba* (Linn.). |
| 16. | River Birch | *Betula nigra* (Linn.). |
| 17. | Blue Beech | *Carpinus caroliniana* (Walt.). |
| 18. | Beech | *Fagus americana* (Marsh) Sudw. |
| 19. | Chinquapin | *Castanea pumila* (Linn.) Mill. |
| 20. | Chestnut | *Castanea dentata* (Marsh) Borkh. |
| 21. | White Oak | *Quercus alba* (Linn.). |
| 22. | Post Oak | *Quercus minor* (Marsh) Sargent. |
| 23. | Chestnut Oak | *Quercus prinus* (Linn.). |
| 24. | Swamp White Oak | *Quercus platanoides* (Lam.) Sudw. |
| 25. | Cow Oak | *Quercus michauxii* (Nutt.). |
| 26. | Red Oak | *Quercus rubra* (Linn.). |
| 27. | Scarlet Oak | *Quercus coccinea* (Muenchh.). |
| 28. | Black Oak | *Quercus velutina* (Lam.). |
| 29. | Spanish Oak | *Quercus digitata* (Marsh.) Sudw. |
| 30. | Pin Oak | *Quercus palustris* (Muenchh.). |
| 31. | Black Jack Oak | *Quercus marilandica* (Muenchh.). |
| 32. | Shingle Oak | *Quercus imbricaria* (Michx.). |
| 33. | Willow Oak | *Quercus phellos* (Linn.). |
| 34. | Slippery Elm | *Ulmus pubescens* (Walt.). |
| 35. | White Elm | *Ulmus americana* (Linn.). |
| 36. | Hackberry | *Celtis occidentalis* (Linn.). |
| 37. | Red Mulberry | *Morus rubra* (Linn.). |
| 38. | Sweet Bay | *Magnolia glauca* (Linn.). |
| 39. | Yellow Poplar | *Liriodendron tulipifera* (Linn.). |
| 40. | Pawpaw | *Asimina triloba* (Linn.) Dunal. |

41. Sassafras .....*Sassafras sassafras* (Linn.) Karst.
42. Witch Hazel .....*Hamamelis virginiana* (Linn.).
43. Red Gum .....*Liquidambar styraciflua* (Linn.).
44. Sycamore .....*Platanus occidentalis* (Linn.).
45. Service-berry .....*Amelanchier canadensis* (Linn.).
46. Scarlet Haw .....*Cratacgus coccinea* (Linn.).
47. Crab Apple .....*Malus angustifolia* (Michx.).
48. Hercules' Club .....*Aralia spinosa* (Linn.).
49. Black Cherry .....*Prunus serotina* (Ehrh.).
50. Wild Red Cherry .....*Prunus pennsylvanica* (Linn.).
51. Sweet Cherry .....*Prunus avium* (Linn.).
52. Ailanthus .....*Ailanthus glandulosa* (Desf.).
53. Redbud .....*Cercis canadensis* (Linn.).
54. Locust .....*Robinia pseudacacia* (Linn.).
55. Holly .....*Ilex opaca* (Ait.).
56. Silver Maple .....*Acer saccharinum* (Linn.).
57. Red Maple .....*Acer rubrum* (Linn.).
58. Box Elder .....*Acer negundo* (Linn.).
59. Dogwood .....*Cornus florida* (Linn.).
60. Black Gum .....*Nyssa sylvatica* (Marsh).
61. Persimmon .....*Diospyros virginiana* (Linn.).
62. Black Ash .....*Fraxinus nigra* (Marsh).
63. White Ash .....*Fraxinus americana* (Linn.).
64. Red Ash .....*Fraxinus pennsylvanica* (Marsh).

## THE IMPORTANT TIMBER TREES AND THEIR USES

The foregoing list of 64 different tree species, all of more or less commercial importance in the county, indicates a diversity of conditions. While a great many of the species named have certain special uses, many others of minor importance are often used as substitutes. Considering only those which by reason of their abundance and good qualities have a wide use, the list may be reduced to comparatively few species.

### THE OAKS

About one-half of the hardwood lumber cut in the county consists of Oak. There is no class of wood which serves so many useful purposes, possessing the qualities of toughness, strength and durability to a marked extent. The Oaks are divided commercially into two groups—the White Oaks and the Red Oaks.

*White Oaks.*—In this group are included a number of different species, usually cut and sold as White Oak without distinction. Indeed, the wood of the different species of this group is scarcely distinguishable except by an expert, and one kind is practically as good as another. The true White Oak furnishes probably 90 per cent of what is cut and sold as White Oak. The other White Oaks constituting the group are Chestnut Oak, Post Oak, Cow or Basket Oak, and Swamp White Oak. The wood of the White Oak is particularly tough and strong, and since it is found in all sections of the county in large sizes it is the most important of all tree species. Its principal uses are for bridge plank, wagon and car stock, framing for buildings and boat keels, railroad ties, cooperage stock, piling, logs for export, and a variety of other uses requiring a high-grade wood.

*Red Oaks.*—A number of different species of Oak are sold as Red Oak, including Black Oak, Spanish Oak, Red Oak, Scarlet Oak, Pin Oak and Willow Oak. Sometimes the last two mentioned are classed as Water Oaks and sold at a somewhat lower price. The chief uses of Red Oak are for framing, lumber, railroad ties, bridge, warehouse and boat planking, with much which is subsequently manufactured into interior finish and furniture. The greatest increase in use during the past ten years has been for railroad ties, which now take a large percentage of the cut. This is due to the railroad companies installing treating plants in which the wood is impregnated with creosote or other preservatives, enabling it to resist decay. This coupled with the natural strength and toughness of the wood, gives excellent results.

### OTHER HARDWOODS

*Chestnut.*—Chestnut is very abundant in most parts of the county and has a variety of uses, the principal of which are telephone, telegraph and trolley poles, railroad ties, fence boards, sheathing, and other rough lumber, fence posts, barrel and keg staves. Prevalence of the chestnut blight has hastened the cutting of many tracts where Chestnut is an important part of the stand, and therefore increased the cut of this species during the past five years.

*Yellow Poplar.*—This species, more properly called the Tulip-tree, is often separated into two classes by woodsmen—one in which the trees

contain a very large percentage of yellowish heartwood, called Yellow Poplar, and those consisting of considerable sapwood, therefore principally white, and called White Poplar. It is botanically the same tree, the difference in the color of the wood being principally due to the rate of growth and possibly to some extent to soil conditions. The better grades of Yellow Poplar are cut and sold for carriage and wagon bodies, furniture stock and interior finish, while a large quantity, particularly of the poorer grades, is used locally for house siding and sheathing. The smaller and medium-sized trees are cut extensively for pulpwood.

*Hickory,* of which two species, the Mockernut and Pignut, are common, is a wood confined to rather special uses, such as spoke timber and tool handles. The tree is found in a variety of situations and generally distributed through the forest. While the wood is valuable, it is a slow-growing species, and under prevailing conditions is not important from a timber-growing standpoint because such a small per cent of the tree is merchantable.

*Locust* is a small tree which is abundant throughout the county on a variety of soils and is the chief dependence for fence posts. It also has special uses in basket-making and for insulator pins in pole line construction.

*Red Gum,* also known as Sweet Gum, is less widely distributed, being confined to wet situations. The large trees are frequently cut into short lengths, which are then manufactured into veneer and used largely for making berry and vegetable baskets. In addition it is used frequently for barrel staves and lumber. The smaller trees are frequently cut for pulpwood.

*Spruce Pine,* also known as Scrub Pine, is the most important of the four Pines that occur in the county, the others being Pitch Pine, Shortleaf Pine, and Loblolly Pine. The Scrub Pine is widely distributed and is found particularly on land that was once cleared, and cultivation later abandoned. It comes in quickly in old fields and often furnishes the transition from unproductive land to valuable forest, since it is generally succeeded by better hardwood growth. It is a tree that does not usually

attain sufficient size for saw timber, but is an important factor in producing large quantities of pulpwood, cordwood and piling.

*Red Cedar* is a tree that is often associated with Pine in old fields, and is particularly abundant along fence rows. The tree grows slowly but is exceedingly durable and hence used extensively for fence posts. There is a limited market for this species in furnishing material for fences and other rustic structures.

## THE LUMBER AND TIMBER CUT

The lumber and timber cut of the county based on data secured in 1912 and further revised to approximate the 1914 cut, shows that the 22 saw mills produced 1,966,000 feet, board measure, of lumber and 225.000 shingles. In addition timber operators produced large quantities of railroad ties, poles, piles, pulpwood, cordwood, mine props, export wood, charcoal, and posts, using altogether 1,230,110 cubic feet of wood.

*Lumber.*—Of the lumber production of 1,966,000 board feet, 1,596,000 was hardwood, valued at the mills at $18 per thousand; and 370,000 feet consisted of softwoods, valued at $15 per thousand, making a total of $34,278.

Of the hardwood lumber, over one-half was Oak, with Chestnut, Yellow Poplar, and several other species in smaller quantities. The softwood lumber cut consisted entirely of Pine, principally Scrub, with a small quantity of Pitch Pine.

*Shingles.*—The 225,000 shingles were valued at the point of production at $4.25 per thousand, making a total of $956. Shingles were cut by a few of the mills for local use and were made almost entirely from Chestnut.

*Railroad Ties.*—Nearly all the railroad ties cut are either Oak or Chestnut. A small percentage consist of Beech, Maple, Sycamore and a few other species, but the quantity so used is practically negligible. 15,894 White Oak ties were produced, and 15,884 Red Oak. The former are worth 70 cents, the latter 50 cents, giving a product worth $19,067. 32,116 Chestnut ties were cut, which, at 20 cents each, amount to $6423, giving a total of $33,514 for 63,894 ties delivered at the railroad. Most

of the ties are gotten out by a few large operators, though some smaller firms and individual farmers are engaged in the business in a limited way.

*Poles.*—The 5175 telephone, telegraph, and trolley poles cut in the county were practically all Chestnut. Valued at $3 each, they were worth $15,525. They varied in length from 20 feet, largely used for local service lines, to the tall 40- and 50-foot poles used on the main lines. The rapid advance of the chestnut blight in the county has had a tendency to place large quantities of Chestnut on the pole and tie markets, and the price of both has been correspondingly reduced.

*Piles.*—The long water front of the east side of the county and the numerous tidal rivers and creeks call for large quantities of piling. The estimated annual production was 180,000 lineal feet, valued at 10 cents per foot, or a total of $18,000. Of this amount about three-fourths was Oak, and the remainder Scrub Pine.

*Pulpwood.*—The pulpwood business has increased considerably in the last few years. The principal species used is Scrub Pine, which contributed 1700 cords, valued at the point of shipment at $6 per cord. In addition 500 cords of Poplar and Gum, valued at $7 per cord were cut, making a total of $13,700 for this product alone.

Trees ranging from 6 to 14 inches in diameter are most in demand by the pulpwood cutters. The bark is peeled and the sticks are cut into five-foot lengths so that a cord of pulpwood measures 160 cubic feet instead of 128, as is the case with cordwood.

*Cordwood.*—The estimated amount of cordwood cut and sold in 1914 was 2700 cords, valued at $3.25 per cord, or $8775. This does not include the large amount that was cut and utilized by the woodland owners themselves. Of the amount named probably two-thirds was Pine, the balance being hardwood, principally Oak.

The chief markets were Annapolis and Baltimore, a small quantity being shipped by boat to towns on the Eastern Shore.

*Export Wood.*—Large, choice logs of Walnut, Poplar, Oak, Hickory and Ash are collected by dealers and shipped to Baltimore for the export trade. It is estimated that 210,000 feet board measure, averaging in value

$30 per thousand, and amounting to $6300, represented the shipment of this class of material in 1914.

*Mine Props.*—The few small shipments of mine props from the county in 1914 amounted to 200 tons, with a value of $2.50 per ton, and $500 for the entire output. Practically all were of Scrub Pine.

*Posts.*—Approximately 10,500 posts, valued at 15 cents each, were cut and sold in 1914 for $1575. This does not include the number that were cut and used on the farms. About three-fourths of them were Chestnut, the remainder Locust and Cedar.

*Charcoal.*—The burning of charcoal is a relatively unimportant industry at the present time, but considerable quantities are used by tinners and others, furnishing in 1914 a market for approximately 50,000 bushels at 10 cents per bushel, giving a product worth $5000.

*Summary of the Lumber and Timber Cut*

| Product | Amount | Unit Value | Total Value |
|---|---|---|---|
| Lumber, Hardwood | 1,596,000 bd. ft. | $18.00 per M | $28,728 |
| Softwood | 370,000 bd. ft. | 15.00 per M | 5,550 |
| Shingles | 225,000 | 4.25 per M | 956 |
| Railroad ties, White Oak | 15,894 | .70 each | 11,125 |
| Mixed Oak | 15,884 | .50 each | 7,942 |
| Chestnut | 32,116 | .20 each | 6,423 |
| Poles | 5,175 | 3.00 each | 15,525 |
| Piles | 180,000 lin. ft. | .10 per ft. | 18,000 |
| Pulpwood, Pine | 1,700 cords | 6.00 per cord | 10,200 |
| Poplar and Gum | 500 cords | 7.00 per cord | 3,500 |
| Cordwood | 2,700 cords | 3.25 per cord | 8,775 |
| Export wood | 210,000 bd. ft. | 30.00 per M | 6,300 |
| Mine props | 200 tons | 2.50 per ton | 500 |
| Fence posts | 10,500 | .15 each | 1,575 |
| Charcoal | 50,000 bushels | .10 per bu. | 5,000 |
| The Cut | 1,099,610 cubic feet | | $130,099 |

## THE TRANSPORTATION FACILITIES AND MARKETS

There is a considerable amount of mature and over-mature timber scattered over the county, in small tracts or as scattered trees in the forests, which should be cut not only to utilize the material while it is at its greatest value, but also to make room for a good second growth. Most of the timber of merchantable size near shipping points or where trans-

portation facilities are good has been cut; much of the less accessible timber has been allowed to stand beyond maturity. Finding a market for scattered timber, or that which is held in small parcels, such as the farmer's woodlot, is often the chief difficulty in the way of practising good forest management. The getting out of saw timber requires special equipment in which it would not pay for the small owner to invest, and furthermore, his lack of experience in handling timber and placing it upon the market would make this plan entirely impracticable. He must, therefore, depend upon the sawmill and timber operators who are equipped for the business to take the trees from the stump and market the product.

A method of selecting the trees to be cut and later marketing the product has been devised by the State Forester, and wherever tried it has worked out satisfactorily. The plan is for the State Forester, or one of his assistants, to examine the woodland upon application, go over the problems with the owner on the ground, and submit a plan of management for his consideration. This is done without cost except for the travel expenses of the forester. Then, if there is timber to be cut, and the owner desires it, the forester will furnish an expert to select the trees for cutting with reference to their present and prospective value. He also marks and measures them, the results being tabulated to show the number of trees of each kind by size and value. This part of the work is done at nominal cost, $3 per day for the expert, and his board and travel expenses. With two laborers to be furnished by the owner, 30 or 40 acres per day can be covered, and the results of the measurements are afterwards worked up in the office of the forester, without additional charge. A statement is prepared giving accurate, detailed information to the owner, with a form of contract for the cutting of the timber, and a statement is prepared for sending to the sawmill and timber operators who are in the market for standing timber, of whom the State Forester has a very complete list of about 1000 names.

By this method those who buy timber are brought into direct touch with the man who has timber to sell. With the complete information as to the amount and value, together with a form of contract that will meet the

needs of the case, the owner is enabled to deal intelligently with the timber buyer in a manner that will protect the interests of both.

The transportation facilities of the county, furnished by four different lines of railroad for a total distance of 88 miles, and a fifth running along the border for 8½ miles, together with excellent water transportation on the eastern side, has brought all timbered areas within reach of the market, resulting in the repeated culling of the forests. The numerous tidal rivers and creeks, that penetrate the county from the east with their deep-water channels, give cheap transportation to Baltimore and Chesapeake Bay points. In the matter of railroad ties, water transportation to Baltimore, Philadelphia and New York has placed them in a position where there is competition, and the higher prices received have often, after deducting freight rates, exceeded the price paid along the railroad right-of-way in the county.

## THE FOREST INDUSTRIES

It is estimated that the number of persons finding continuous employment in the forest industries of Anne Arundel County is about 375, or a proportionately greater number for shorter periods of time; and that these industries represent capital invested of $400,000. The raw products sold are valued at $130,099, and those manufactured at about $60,000 more.

The "forest industries" of any place fall naturally under two heads—producers, and users of wood and timber in any form. The former get out the raw material; the latter manufacture it. The producers give employment to about three-fourths of those engaged, and represent about one-half the total capital. They are well distributed over the entire county, from Severn in the northern section to Fairhaven in the south, and from Annapolis on the Bay to Woodwardville in the western portion. The manufacturers are restricted to two districts, Annapolis and Brooklyn.

Producers of wood comprise 22 timber operators, a few getting out ties, telephone poles, piling, and special products, but the majority of them cutting lumber. There are six sawmills which may be classed as permanent or stationary, and the remainder are the small, familiar portables, which move about from place to place, cutting timber where they can find

it. These mills cut some Pine, nearly five times as much hardwood, and their average cut per annum is probably not more than 100,000 feet board measure. Undoubtedly many of them are producing more, but there are others cutting much less through a short operating season, so that their average output is not great. The operators send their products to nearby points inland, or market them via the water route in New York, Philadelphia, and Baltimore, particularly the latter. The mill product is secured locally, and for the most part marketed outside.

In the city of Annapolis there are four firms which deal in lumber, handle builders' supplies, and do manufacturing in such general planing-mill products as sash, doors, and blinds. This, however, is the least important part of the business, as much of such material is brought in already manufactured, there being a good demand and a low price for such products shipped there from as far west as the Pacific Coast. There are no box or furniture factories now in Annapolis, and but two of the local yards which give any attention to the manufacturing end of the trade. From here to the northern section of the county there are no manufactories whatever outside of sawmills and similar plants for the production of rough timber. At Brooklyn, East Brooklyn, and Curtis Bay are two yards, a box factory, and a car and foundry plant of considerable size. The former, at Brooklyn, do little manufacturing except in sash and window frames, but the latter, the box factory situated at East Brooklyn, and the car company at Curtis Bay, are users and manufacturers of Pine.

About 23 per cent of the forest products locally produced are Pine; 78 per cent of those used in manufacturing are softwoods, with a great preponderance of Pine. While the annual lumber and timber cut disposes annually of the very considerable amount of 1,099,610 cubic feet, the wood-using industries of the county, few in number, require yearly more than 1,500,000 cubic feet. Of this last, 11 per cent is locally produced, showing that in the markets for Anne Arundel County wood there is opportunity for much development. Good outside markets are open to the wood and timber of this county, but others nearer home may be developed to the further advantage of both divisions of this industry.

## DESTRUCTIVE AGENCIES

The forest may be regarded as an organism in which a vast number of trees of different species and varying requirements are struggling for existence or supremacy. Where this is properly regulated by forest management, the maximum yield is secured. On the other hand, where the forest is regarded as a more or less inexhaustible resource from which all material of value can be taken without thought of the future, rapid deterioration follows. There are various destructive agencies which must be constantly combated in maintaining the forest in its highest state of efficiency and productivity. The most important is that of forest fires, which every year do many thousands of dollars worth of damage; since nearly all fires are the result of carelessness, it is a loss that is inexcusable. Destructive and wasteful methods of cutting are also responsible for much of the waste land and low production of the forest. Insects and fungous diseases are always present, and only awaiting a favorable opportunity for serious outbreaks.

### *Forest Fires*

Forest fires continue to be the chief source of damage to the forest. There is a general lack of appreciation of the damage that fires do. In consequence most fires are the result of carelessness, and as the damage is not fully appreciated, the actual conditions must be forcibly expressed and the education of public sentiment encouraged fully. It is safe to say that the yield from the forests in the northern half of the county is to-day not half of what it might normally be made, due largely to continued forest fires. A few hours fire will destroy the tree growth of generations; the present value is reduced, and the prospective value sacrificed.

The forest fire record for 1914 shows that 34 fires burned over 1196 acres of woodland and caused a damage of $4535. Most of the fires occurred in the northern part of the county. Of the 34 fires, 21 were of unknown origin, 10 from brush burning, 2 from sawmills and 1 from railroads. The amount of damage does not include the destruction of

the very young growth, the soil cover, and the loss to the producing power of the forest. If this were added, it would materially increase the figures given.

The state maintains a fire protection organization in the county consisting of a number of Forest Wardens and a Forest Patrolman. The names and locations of the wardens are given below:

| | |
|---|---|
| Annapolis | Henry C. Whiteford. |
| Birdsville | Hezekiah Best. |
| Chesterville | M. Burch Beard. |
| Gambrill | R. H. Maynard. |
| Millersville | Wm. E. Johnson. |
| Millersville | Nelson Stinchcomb. |
| Odenton | [1] Wm. E. Phelps. |
| Robinson | Dungan McKinsey. |

Forest Wardens are regularly commissioned officers with full authority for fighting forest fires. All wardens are authorized to employ assistants and use any means that may be necessary for controlling forest fires. Each landowner is required to do all that he can in controlling fires on his own holdings, but where he is unable to do so, the Forest Warden will supplement his efforts by employing men at the expense of the state and county to extinguish the forest fire. Whenever a fire occurs, the Forest Warden should be quickly notified so that he may take prompt measures to suppress it, thereby limiting the area burned and the amount of damage caused. Promptness in reporting fires is second in importance to preventing them.

### *Pasturing Woodlands*

The practice of using woodlands for grazing cattle is very detrimental to young growth and should not be allowed in any but the fully-stocked stand where a sufficient number of trees have grown beyond the reach of cattle. The damage from grazing cattle is caused by their eating the tender shoots of small trees, injuring the bark of larger ones, and killing the seedlings outright by trampling. Open, unproductive places are created where the young growth is killed, the ground packed by constant

[1] Forest Patrolman.

trampling, and the rich top-soil destroyed, the earth beneath soon becoming so hard and dry as to retard the growth of the trees. Where there is good forest growth there would be little pasture, and there is nothing that will so quickly destroy a thicket of young growth, which would in time make good timber, as close pasturing. Good timber and good grazing are impossible on the same area; they cannot be successfully combined.

### *Insects and Fungi*

There are a number of injurious forest insects in the county which are very difficult of control. Normally they are held in check by their natural enemies, yet occasionally there are outbreaks that cause considerable damage. Forest insects cannot be controlled like those that attack fruit trees, since it is impracticable to spend a considerable amount of money in the treatment of individual trees. The same practice on the taller, larger forest trees would make the cost of saving a tree many times more than it is worth. The main reliance must be placed upon preventive measures, clean management, and the prompt removal of the dead trees and wood which harbor insects. Dying or defective trees should also be cut and utilized, for insects will often attack trees which possess little vitality and a low power of resistance, rapidly multiplying and then successfully attacking those which are still strong and vigorous.

### *The Chestnut Blight*

The one serious fungus that is now prevalent is the Chestnut Bark Disease, or Chestnut Blight, as it is more generally known. This fungus, *Diaporthe parasitica,* attacks only the Chestnut and Chinquapin. The presence of the disease is usually first apparent by the dying of a branch of a tree in full leaf; closer examination will disclose a dead sunken patch of bark, reddish in color, which extends completely around the branch at the base of the dead portion of the tree. It will be found that the disease has spread from the point of attack in the inner bark until it has completely girdled and killed the branch. This is usually accomplished the first season. Further examination will show that this dead, smooth

bark in the form of a sunken patch, or lesion, is covered with small yellowish pustules the size of a pin-head, perhaps larger, which are in fact fruiting bodies of this particular fungus, each containing minute spores (corresponding to seeds), through which the disease is transmitted to other portions of the same tree or others. These spores may be carried down to the lower portions of the tree by rains, or distributed by winds, birds, and insects, squirrels or other animals, and wherever the spores find an opening through the bark—cracks, wounds, holes of boring insects, cuts or other abrasions—the disease will find entrance.

Instead of being first apparent in the branches, taking several years to kill the tree affected, as it will eventually, the disease may instead attack the thick bark of the trunk, and the entire tree will usually be killed within a year. Where the disease occurs in the thick, furrowed bark, the latter changes but little in outward appearance, the presence of the fungus being indicated by the reddish-yellow pustules, which in this case appear in the crevices of the bark. The latter gives out a dead, hollow sound when tapped with a hammer, and if a portion of it is removed the inner part will be found a spongy, decayed mass.

No methods of control are efficacious where the disease is prevalent. When fully-stocked or over-mature stands require thinnings, the Chestnut should be cut clean as far as possible, for it is not practicable in the forest to spray or to apply other remedies that are used to save orchard or shade trees. The expense of the operation and inability to reach diseased portions of large trees makes it impossible to practise intensive work of this kind. When the disease is confined to the branches, it may be possible by careful pruning to eliminate it, and this is often resorted to in the case of valuable shade trees. In the forest it is impracticable and impossible. Much, however, can be accomplished by clean methods of management and sanitation. It is a well-known fact that many destructive insects breed or live through the winter in dead wood. By keeping the trees and the branches that fall or are broken down, as well as the standing trees that evidence the first signs of death, closely utilized, insects may always be more successfully controlled. The same is true in the control of

fungous diseases; the Chestnut Blight is typical of this class. The wood of the trees killed is not injured, and since any tree attacked is certain to die, it should be cut and utilized while it is yet sound. In the past, utilization of affected trees has proven more prolific of result than prevention of the disease itself.

## FOREST MANAGEMENT

Forest management is "the practical application of the principles of forestry to a forest area." In short, it is the science of making woodlands pay—making them pay in wood, timber or other forest products, and so in money. Good management is made up of judicious cutting, careful logging, efficient protection, and the encouragement of the better species; poor management allows promiscuous removal of valuable trees, lack of care in protecting those which are left, forest fires, and unrestricted grazing. The object of one is to produce the heaviest crop of the best quality in the shortest time. The result of the other is a rather common type of woodlot, culled of the best growth, not fully stocked, and with a production not one-half of normal. Tree growth in the open produces volume and cordwood. Close forest growth gives quality and merchantable timber, and to be at its best the farmer's woodlot must be composed of the right species, not too uneven-aged, and the whole stand dense enough to shade the forest floor. Essential to these are the prevention of fire and grazing. The latter is the more easily accomplished of the two, and in most cases should be restricted if not entirely eliminated. Pasturage and timber culture can rarely be combined to the advantage of either, for the damage through trampling and browsing to young and growing trees is too apparent to need elaboration. A rough fence of material easily secured from the woodlot will soon pay for itself. Here and there through the woods, roads or spaces cleared for 6 or 8 feet should, by dividing the large tract into smaller blocks, lessen the fire hazard, and cleared strips should also be along the rights-of-way of railroads or property lines where they may touch the forest. Anne Arundel is less likely than some other counties to suffer from fires caused by railroads, for electric lines

make up a large proportion of its total mileage. The county has an efficient force of State Forest Wardens who co-operate with the public in preventing and stopping all woods fires.

Rates of growth in the natural and the planted stand differ much in favor of the latter. However, more even-aged composition may be secured in the former through consistent treatment and selective cutting, and the open spaces may be planted with trees adapted to their conditions. The State Forest Nursery will furnish to Anne Arundel landowners, at cost, trees of the right age for planting in several well-known and valuable varieties—White and Loblolly Pines, Norway Spruce and Douglas Fir, European Larch, Tulip Poplar, Black Walnut, White Ash, Elm, Black Locust, Red and White Oaks. The planting has usually been done in the spring, but in this county it should also be possible in the fall, and trees from the nursery may be secured at either time. More than 41,000 acres of Anne Arundel County soils are waste and unproductive, and these, whatever their character, whether dry sands or marshy lands, may be profitably reclaimed through judicious tree-planting. Such operations increase the soil fertility, improve the general situation and value of the farm itself, and exert a beneficial influence upon general conditions of soil and water. Advice will be given by the state as to how and what to plant, and following the practice of past years the State Forester will visit and advise on the treatment of any woodlot in the county. For such service no charge is made save for the expense of traveling and maintenance. Treatment of the stands visited may also be indicated on the ground, and carried out at low cost, this work being fully described in Leaflet No. 18, published by the State Board of Forestry.

## PRESENT AND FUTURE OF THE FORESTS

On the 92,266 acres of forest land there is a stand of 128,517,000 board feet, approximately 10,666,911 cubic feet, of hardwood and softwood timber. In their present condition it is probable that the average annual increment of merchantable material cannot, on this tract as a whole, be in excess of 18 cubic feet per acre. The annual increase, then, is 1,660,788

cubic feet per annum. Opposed to this natural addition to the forest capital is a great volume of wood used for fuel and fencing on nearly every one of the county's 1889 farms. It amounts to 2,002,340 cubic feet each year, and is substantially supplemented by the 1,099,610 cubic feet of material which is cut and marketed as lumber, ties, poles, and other products of the local timber industry. The total is 3,101,950 cubic feet of wood.

The cut is obviously far greater than can be constantly supplied, for the cut exceeds the growth by 86.8 per cent. This excess cut has been kept up for many years, but it will not be possible for many more. If that of last year is maintained, and it is probable that for a time at least it will be, the timber at present standing, and that now growing, will be consumed in 7½ years. As the remaining stand is cut down in quantity and area, and reduced in quality, this present cut will no doubt slacken somewhat. But it is problematical if Anne Arundel, after 10 or 15 years, will realize much from the sale of forest products if such conditions are continued. Salable wood and timber in different forms brought $130,099.00 to residents of the county in 1914; other products not sold, but used at home, were worth as much or more in actual monetary saving and utility to the farmers who made use of 2,002,340 cubic feet of cordwood and fencing during the same period. It is doubtful if Anne Arundel County, with the possible exception of its fisheries, has a natural resource comparable to this; few, if any, industries that bring more revenue at less real outlay to the owner. Should this resource, then, be encouraged to greater usefulness? The answer lies with the individual owner, who in most cases is a farmer. With practical, up-to-date methods of agriculture extended to the woodlot, the present revenue may be increased and assured. Without such care, in a decade it will be negligible.

Right handling may double present production. When that is so, these figures show that consumption and production will very nearly meet, and such management should not only increase the quantity of the product; it should bring about a distinct betterment of quality. Improvement in both of these, added to a rise in the prices of forest products which the

next few years should bring about, would make entirely possible an annual revenue of close to a quarter-million dollars. The present area of forest land will be reduced, as it should be, by the clearing of land which will grow good crops, but it should be offset by reforestation of a considerable part of the 42,000 acres of lands now classed as "waste." The planted forest surpasses in nearly every way that seeded naturally, and such an area, reforested, possesses great possibilities in forest culture. Commercially valuable trees planted for saw timber, under fairly favorable conditions, will yield as high as 500 board feet per acre per annum on the basis of a 40- or 50-year rotation. If the waste lands of the county were reforested with a paying crop it would make possible, once fairly started, a production as great as the present cut. The planting of timber trees on the non-agricultural lands of Anne Arundel County is strongly recommended to the farmer.

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